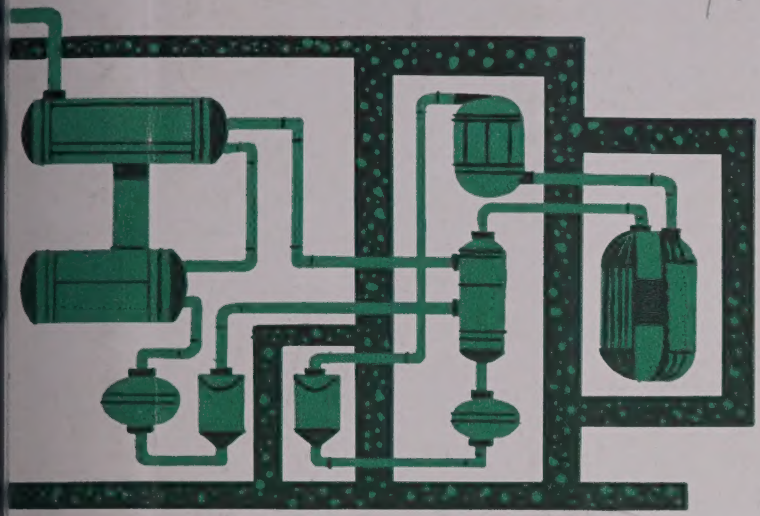
R/E

RESEARCH & ENGINEERING

MAGAZINE OF RESEARCH & DEVELOPMENT MANAGEMENT

OCTOBER-NOVEMBER 1955



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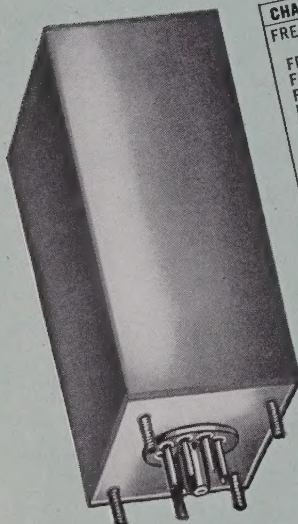
Covers the frequency band from 400 cps to 70 kc. 3 DB Band width ±9¾% of center frequency. Features octal "plug in" header. Size 2⅛" x 3½" x 4½".



CHARACTERISTIC IMPEDANCE 2500 OHMS

FREED #	CENTER FREQUENCY	3 DB BAND WIDTH
FBP-34	400 cps	± 9¾% CF
FBP 35	560 cps	± 9¾% CF
FBP 36	730 cps	± 9¾% CF
FBP-37	960 cps	± 9¾% CF
FBP 38	1300 cps	± 9¾% CF
FBP 39	1700 cps	± 9¾% CF
FBP-40	2300 cps	± 9¾% CF
FBP-41	3000 cps	± 9¾% CF
FBP-42	3900 cps	± 9¾% CF
FBP-43	5400 cps	± 9¾% CF
FBP-44	7350 cps	± 9¾% CF
FBP-45	10500 cps	± 9¾% CF
FBP-46	12300 cps	± 9¾% CF
FBP-47	14500 cps	± 9¾% CF
FBP-48	22 KC	± 9¾% CF
FBP-49	22 KC	±19½% CF
FBP 50	30 KC	± 9¾% CF
FBP-51	30 KC	±19½% CF
FBP-52	40 KC	± 9¾% CF
FBP-53	40 KC	±19½% CF
FBP 54	52.5 KC	± 9¾% CF
FBP-55	52.5 KC	±19½% CF
FBP 56	70 KC	± 9¾% CF
FBP 57	70 KC	±19½% CF

CHARACTERISTIC IMPEDANCE 500 OHMS

Band pass filters FBP-10 through FBP-33 feature the same attenuation characteristics as the above listing and are supplied with solder lug terminals.

DISCRIMINATOR INPUT LOW PASS FILTERS

Covers the frequency band of 400 cps to 70 kc. Less than .05 DB attenuation at ±9¾% of center frequency. 30 and 50 DB attenuation at the third and fifth harmonic of the pass band frequencies. Size 1½" x 1½" x 4½".

CHARACTERISTIC IMPEDANCE 30,000 OHMS

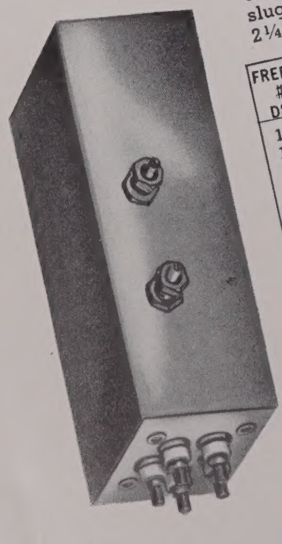
LPI —	Fo
10	400 CPS
11	560 CPS
12	730 CPS
13	960 CPS
14	1300 CPS
15	1700 CPS
16	2300 CPS
17	3000 CPS
18	3900 CPS
19	5400 CPS
20	7350 CPS
21	10.5 KC
22	12.3 KC
23	14.5 KC

CHARACTERISTIC IMPEDANCE 5100 OHMS

LPI —	Fo
24	22. KC
25	30 KC
26	40 KC
27	52.5 KC
28	70. KC

SLUG TUNED DISCRIMINATORS

Covers the frequency band of 3 kc to 70 kc. Frequency deviation ±8½% of center frequency. ½% linearity. Features slug tuned adjustment. Size 1⅝" x 2¼" x 4½".



FREED # DST	Fo	FREQUENCY DEVIATION	LINEARITY	DC OUTPUT
17	3 KC	± 8½% Fo	WITHIN .5%	32.5V
18	3.9 KC	± 8½% Fo	WITHIN .5%	32.5V
19	5.4 KC	± 8½% Fo	WITHIN .5%	32.5V
20	7.35 KC	± 8½% Fo	WITHIN .5%	32.5V
21	10.5 KC	± 8½% Fo	WITHIN .5%	32.5V
22	12.3 KC	± 8½% Fo	WITHIN .5%	32.5V
23	14.5 KC	± 8½% Fo	WITHIN .5%	32.5V
24	22 KC	± 8½% Fo	WITHIN .5%	32.5V
25	30 KC	± 8½% Fo	WITHIN .5%	32.5V
26	40 KC	± 8½% Fo	WITHIN .5%	32.5V
27	52.5 KC	± 8½% Fo	WITHIN .5%	32.5V
28	70 KC	± 7½% Fo	WITHIN .5%	32.5V
29	22 KC	±15% Fo	WITHIN 1%	26V
30	30 KC	±15% Fo	WITHIN 1%	26V
31	40 KC	±15% Fo	WITHIN 1%	26V
32	52.5 KC	±15% Fo	WITHIN 1%	26V
33	70 KC	±15% Fo	WITHIN 1%	26V

FIXED DISCRIMINATORS

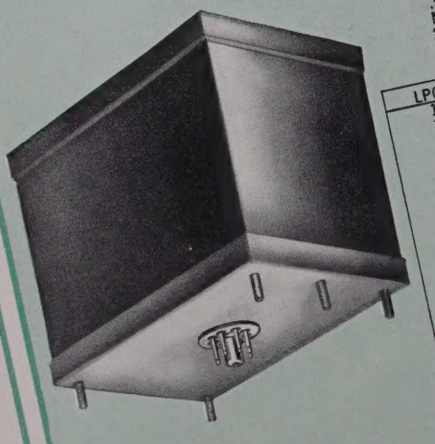
10	400 cps	±8½% Fo	WITHIN .5%	32.5V
11	560 cps	±8½% Fo	WITHIN .5%	32.5V
12	730 cps	±8½% Fo	WITHIN .5%	32.5V
13	960 cps	±8½% Fo	WITHIN .5%	32.5V
14	1300 cps	±8½% Fo	WITHIN .5%	32.5V
15	1700 cps	±8½% Fo	WITHIN .5%	32.5V
16	2300 cps	±8½% Fo	WITHIN .5%	32.5V

DISCRIMINATOR OUTPUT LOW PASS FILTERS

Covers the frequency range from 6 cycles to 10,000 cycles. Features octal "plug in" header. Size 4" x 6" x 4½".

CHARACTERISTIC IMPEDANCE 330 OHMS

ATTENUATION: LESS THAN .2DB UP TO .5 TIMES Fo
LESS THAN .7DB FROM .5 Fo TO 1. Fo
MORE THAN 20DB AT 2 TIMES Fo
MORE THAN 30 DB FROM 3 TIMES Fo TO 100 KC



LPO—	Fo
10	6 CPS
11	8 CPS
12	11 CPS
13	14 CPS
14	20 CPS
15	25 CPS
16	35 CPS
17	45 CPS
18	60 CPS
19	81 CPS
20	110 CPS
21	160 CPS
22	185 CPS
23	220 CPS
24	330 CPS
25	450 CPS
26	600 CPS
27	660 CPS
28	790 CPS
29	900 CPS
30	1050 CPS
31	1200 CPS
32	1600 CPS
33	2100 CPS
34	7200 CPS
35	10000 CPS

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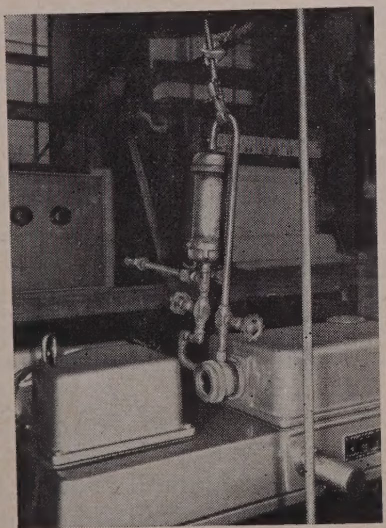
P-E Analytical News

Analyzing for Impurities in Liquid Chlorine

Estimating impurities in liquid chlorine is no picnic. Although contaminants are present in only a few parts per million, it's important for commercial chlorine makers to know how much and of what.

The analytical obstacles are enough to make the staunchest chemist blanch. Several liters of sample are required. Conventional analytical methods eat up loads of time. And if you use the most reliable method, distillation, you may wind up with a different impurity than the one with which you started.

But recently researcher A. W. Pross of the Central Research Laboratories, Canadian Industries, Limited has worked up an infrared analytical procedure — and now, with an assist, we are proud to say, from Perkin-Elmer, infrared analysis is eminently practical for routine commercial estimation of liquid chlorine impurities.



It seems that liquid chlorine is extremely transparent to infrared radiation. Which means you can use a cell path-length some 2000 times greater than is usual for most organic liquids. And long path length means high sensitivity to absorbing substances — on the order of a few ppm which is just what we're shooting for.

The special long path cell, designed here at P-E, is fitted to a stainless steel reservoir and needle valve system. This makes it possible to fill the cell with liquid chlorine directly from an inverted commercial cylinder. When filled, the reservoir and cell are supported in front of the business end of a Perkin-Elmer Model 12-C single beam spectrometer, with a calcium fluoride prism. Calcium fluoride prisms give higher resolution than rock salt, and high resolution is a *sine qua non* in this type of analysis.

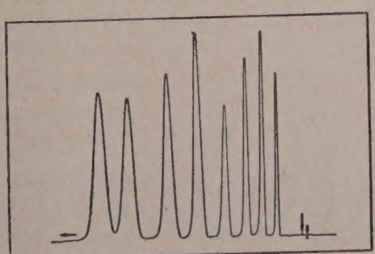
Quan and Qual Made Easy!

Awhile back P-E heard rumors that many chemists, asked to analyze particularly stubborn mixtures of gases or volatile liquids, become prone in a short time to aspirin addiction in its more severe forms. They complain of long, hard labor operating distillation columns or mass spectrometers, with only fair results. And they feel guilty using expensive equipment and giving little return on the investment.

Now at that time P-E was working with gas chromatography, a perfect solution for this very problem. The Vapor Fractometer was the result. This new tool, for analyzing gases and volatile liquids boiling below 300°C, takes advantage of the different affinities which materials have for one another to separate a mixture into its component parts.

Both equipment and analytical procedures are extremely simple, yet results in most cases equal or surpass those obtained from other methods. Fast, clean separations are made, and sensitivity of the detector plus recorder makes accurate quantitative determinations a breeze. Yet the Vapor Fractometer, with all these advantages, costs from 5 to 20 times less than old standby instruments.

Take LPG analysis, where most components cannot be cleanly separated by ordinary techniques. In operation, a metered sample of gas is blown through a column. The various components of the sample move through at different rates, depending on their affinity for the material in the column. Each arrives at the column end at a slightly different time to pass through a detector.



In a few minutes a series of peaks appears on a recorder, the first for the fastest moving component, and so on down the line. Area under each peak is proportional to the amount of the component present in the mixture. Analysis shown took 23 minutes. Not only are compounds separated cleanly, but perfect shape of recorder bands makes quantitative analysis very accurate.

We'd be glad to work out applications to particular problems with those chemists who prefer the quick, easy approach, and those management men who hate to spend unnecessarily.

"NMR" — A New Analytical Tool

The phrase "Nuclear Magnetic Resonance" probably sounds completely foreign to the average chemist today, but it may well be in common usage in the laboratory of tomorrow. This recently discovered phenomenon has the look of a powerful new analytical tool. Essentially, this is it:

Most atomic nuclei behave as if they were spinning about an axis like tops, and seem to have small magnets parallel to the magnetic field. For a given magnetic field, the frequency of resonance for each isotope is a discrete value. The ratio of the magnet strength or magnetic moment value to spin value for a given nucleus, the "gyro magnetic ratio," is a constant. Since these ratios are different for different nuclei, the gyro magnetic ratio provides a means for identifying nuclei.

If a group of nuclei are placed in a magnetic field, they will tend to line up according to the specific orientations (spins) permitted them. If, in addition, a varying r.f. signal of the correct frequency is applied, the nuclei will precess. In essence, the nuclei resonate at this frequency and, in so doing, absorb some of the r.f. energy. Resonance frequency for a given nucleus is a function of strength of magnetic field and the gyromagnetic ratio of the nuclei involved.

In its simplest form, then, a nuclear magnetic spectrometer consists of a magnet, an r.f. generator, a simple coil and r.f. detector. A plot of r.f. energy absorption versus frequency constitutes a nuclear magnetic resonance spectrum.

P-E has set up a subsidiary to develop instruments based on this phenomenon. Now available: a broad band spectrometer and a magnetic field control system. Available soon: a fluxmeter and a high resolution spectrometer.

Perkin-Elmer Corporation, 808 Main Avenue, Norwalk, Connecticut

We'll be glad to send you more information on any of these items. Or to put you on the mailing list for INSTRUMENT NEWS, a quarterly published by P-E to further research, material analysis and production through electro-optical instrumentation.

an announcement

and a short course in the publishing profession

In this issue we have combined the November with th October issue—and thereby hangs an interesting story.

Years ago a large publishing company brought out new "picture magazine" for the general public. It "caugh fire" with the public so much faster than anticipated, o hoped for by the publishers, that the necessity for pro ducing a bigger editorial package for its clamoring reader brought the work load on its producers close to a breakin point.

On a much smaller scale, that is what is happening t RESEARCH & ENGINEERING, this new magazine fo industrial research, development and design managers. I our first issue, which appeared in July, we had one sentenc buried in a solid page of type like this, in which we aske for comments and suggestions from readers.

Came the Flood

In less than a week, letters started coming in—by th dozens—then by the hundreds—until now we have almos 2000 such letters and the tide is ebbing only slowly. S far only two have registered dissatisfaction and we we come those two as much as the other 2000 that were com plimentary. More important, however, is the great fun of sensible suggestions that have been received and man of which will be incorporated in future issues of R/E

As publishers, this deluge brought us up short. R/I is not a sudden "flash of inspiration"; the basic concep of the magazine was first established over eight years ag and like any modern industrial development project, wa analyzed, tested and researched thoroughly before its firs appearance.

But we, too, did not expect this magazine to "catch fire so rapidly. We were staffed editorially to produce a slowly evenly rising editorial content; our plans, laid long ago were to produce issues of between 32 and 48 pages betwee July and December of this year, adding to our editoria staff as the months went by until in January we would b ready to produce a much larger editorial content on a regu lar monthly basis.

Instead, we have decided to add part of the planned edi torial material of the November issue to the October issue to give the breadth of coverage desired—then devote a our time to manpowering-up for a greater editorial cover age each month beginning in January.

We mentioned in our September issue that we were try ing to answer each of your letters; if you haven't receive a reply, we hope you will understand our situation. If you have further comments or suggestions, please write us

Wm. H. Relyea, Jr.

PUBLISHER

Introducing

3 NEW ALKATERGES

compare these
new versatile
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Compare the physical properties of these new additions to the CSC family.

Physical Properties	Alkaterge C	Alkaterge A	Alkaterge E	Alkaterge T
Color, Gardner (1933)	15	7	7	7
Solidification Point, °C	—40	—41	—50	59
Specific Gravity @ 20/20°C	—	0.885	0.926	—
Specific Gravity @ 25/25°C	0.925	0.883	0.924	—
Wt. per US Gallon @ 68°F, lbs.	7.71	7.37	7.72	—
Coefficient of Expansion, per 1°F	0.00067	0.00061	0.0043	—
Refractive Index, n_D @ 25°C	—	1.4631	1.4738	—
Viscosity:				
Saybolt Universal @ 100°F. sec.	—	79.9	299	—
Centistokes @ 100°F	71*	14.5	62	—
Interfacial Tension Against Water, dynes/cm:				
0.1% solution in mineral oil	2	24.6	18.1	1.8
1% in m.o. against sat. aq. sol'n	—	10.5	3.7	—
Surface Tension, sat. aq. sol'n. dynes/cm:	42	37.6	37.8	30.4
Flash Point, Cleveland Open Cup, °F	400	325	395	None
Solubility, ml/100 ml:				
In Water	0.005	0.005	0.4	0.01
Water in product	—	3.8	2.56	—

*at 96°F

Now, Commercial Solvents offers three new surface-active agents that are closely related to ALKATERGE-C. Because of the latter's proven industrial usefulness, demand exceeds supply. Production facilities are being expanded. Many of CSC's customers have found that ALKATERGE-A, -E, or -T do equally well or better in many of the jobs formerly accomplished by ALKATERGE-C. While they differ somewhat in individual properties, they should prove useful as auxiliary emulsification agents, antifoam agents, dispersing agents, spreading agents, pigment-grinding assistants, acid acceptors and in numerous other applications. Test all or any of these three new alkaterges for yourself. For complete information and a sample, write to Market Development Department, CSC, 260 Madison Ave., N.Y. 16, N.Y.

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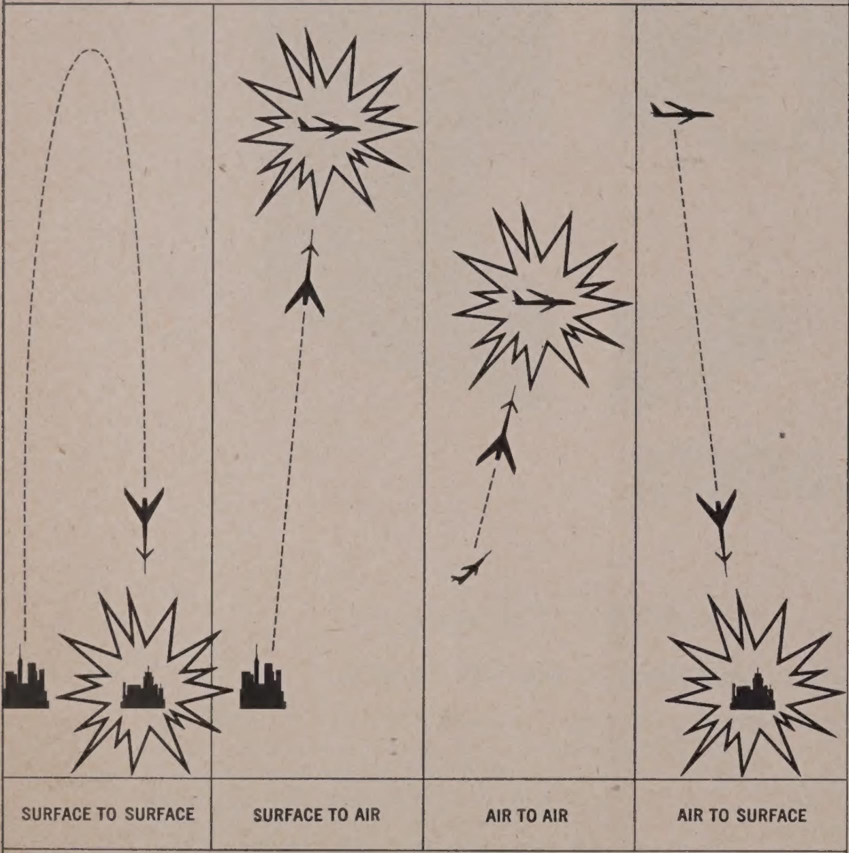

Nearly all guided missiles require specialized and highly advanced electronic systems of miniature proportions. These systems may include servo-amplifiers, microwave receivers and transmitters and extremely efficient though compact power supplies. The performance objectives for this equipment would be difficult in conventional engineering applications.

At Hughes, the achievement of such objectives in the very limited space and under stringent environmental conditions of the modern guided missile provides an unusual challenge to the creative engineer.

Positions are open for Engineers or Physicists with experience in systems analysis, electronic guidance systems, infrared techniques, miniature control servo and gyro systems, microwave and pulse circuitry, environmental testing, systems maintenance, telemetering, launching systems and flight test evaluation.

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Culver City, Los Angeles County, California

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Letters

More Management

St. Paul, Minn.

. . . looks like a useful journal and I would appreciate being put on your circulation list. Our Engineering Research Department is only a few years old, and we are very interested in finding out how other similar groups are organized. Future articles . . . on organization charts, duties, functions and financing of other Engineering Research groups would be welcomed.

W. R. LUDKA, MGR.
Engineering Research
MINNESOTA MINING & MFG. CO.

Tool—Not Panacea

Portland, Ore.

. . . it is hard to believe, but unfortunately true, that of all the periodicals published in the industrial fields there has not been, until the advent of R & E, a magazine devoted directly to people whose job is to create and promote creation of new and improved products out of existing raw materials and tools. There are so many periodicals which overlap in the field of presenting monthly lists or news items of new products, but keeping up with new products alone is in itself only another tool, not a panacea. What is needed is a periodical which analyzes and which reports on research and research management techniques and philosophies, and which serves, even unofficially, as a clearing house for professional ideas and as a symbol of the profession itself. . . . I would say that this periodical could be the one to do all that, and more. It was extremely well done, and we are looking forward to seeing other issues.

M. J. MERRICK
Chief Research Engineer
SAWYER'S INC.

Timely

Fullerton, Calif.

. . . I am very much impressed by the content of this publication and the manner in which the subject matter has been covered. Your initiating a trade magazine to cover this very important area of our expanding technology is certainly timely and well received.

RALPH S. WHITE
Chief Administrative Engineer
BECKMAN DIVISION
BECKMAN INSTRUMENTS INC.

Expeditious

Carlisle, Pa.

. . . should surely fill a need . . . felt for some time in expediting exchange of management information in the R/E field.

GEORGE W. ZIEGLER, JR.
Administrator
AIRCRAFT-MARINE PRODUCTS INC.

Ultrasonics

Pittsburgh, Pa.

We have learned of the existence of your publication and of an article relative to ultrasonics and its applications . . . by Robert L. Rod . . . If you have available a copy of Mr. Rod's article, we should be delighted to receive it . . . I should be pleased also if you would forward some information about your magazine. It seems to me that we should be subscribers.

ALLISON L. BAYLES
ALLISON L. BAYLES & ASSOCIATES
CONSULTING MANAGEMENT ENGINEERS

Gap Filler

Newark, N. J.

I would like to take this opportunity to congratulate you on the presentations in your new publication . . . your magazine fills an excellent gap left open by the so-called 100% scientific trade publications. Certainly, the future success of all those who guide research and development is not confined to technical "know how" but also the ability of the head of a research department to handle the "Dale Carnegie approach" which has been so excellently described in your recent articles.

IRA KAMEN
Vice-President in Charge
Research & Development
BRACH MFG. CO.

Gap Bridger

Chicago, Ill.

. . . At first glance your publication appears to fill a great need for a periodical to bridge a gap between the usual Management-Personnel type of literature and the many technical magazines that specialize in reporting activities in various engineering fields. Much of the information from many of the former is not specifically adaptable to our particular problems while the latter have multiplied and specialized to such an extent that it is quite difficult to keep abreast of current development trends. We would also suggest that you refrain from attempting to list newly developed products on which we note a great number of magazines are repeating ad nauseum the promotional claims of their manufacturers.

R. D. SLAYTON,
Chief, Product Research Dept.
TELETYPE CORP.

Our editorial research based on small sampling techniques indicated that many readers would be interested in a supplement containing very brief descriptions of "what's new and where to get it". Our first supplement, section two of this issue, faces page 48. We will be happy to receive comments from readers on the extent to which such a supplement can be useful—Ed.

Will Circulate

New York, N. Y.

I read R & E with great interest . . . and was extremely impressed with the contents. A magazine along the lines indicated by your prospectus fills a long felt need, in my opinion, for some intermediate ground between the pure science and wholly practical application thereof. I would like very much to be placed on your circulation list, for subsequent issues and assure you that these will receive a wide circulation in our company.

LEON MOLLICK
Chief Stress Analyst
LOEWY CONSTRUCTION CO., INC.

Form and Substance

Oak Ridge, Tenn.

Having read your first issue of R & E with a great deal of interest, I wish to commend you on the format and substantive content of this magazine which should serve a most useful purpose in the field of industrial and government research.

PAUL C. AEBERSOLD
Director, Isotopes Div.
U.S. ATOMIC ENERGY COMMISSION

Long Sought

Chicago, Ill.

Congratulations on your excellent publication. R/E is the long sought answer for a magazine that provides coordinated and maximum concentration in research and development management. Our entire staff is pleased with the extent of your coverage . . . Your subjects are well chosen and excellently covered. We look forward to your next issue.

JAMES S. ROSS
President
INTERNATIONAL PROCESSES, INC.

Broad Perspective

Washington, D. C.

Congratulations! . . . have had an opportunity to read the second issue of R & E and wish to compliment you on your editorial policy. You have succeeded in selecting and presenting information of great interest to the administrator of research and development. In our rapidly advancing technology it is essential that management alert itself to the implications of progress in many scientific disciplines. I hope that R & E will continue to maintain the broad perspective that has been demonstrated in the first two issues. I would appreciate receiving a personal copy . . . which can be circulated to other members of our staff.

R. S. WERNER
Scientific Staff Assistant
Radio Division
NAVAL RESEARCH LABORATORY

Helpful

Detroit, Mich.

. . . the articles . . . at least with respect to problems in directing and defining research and engineering to the point, have helped others in the organization realize just what research problems can be and how difficult they are sometime.

J. B. CATALDO
Director Research & Development
BULLDOG ELECTRIC PRODUCTS CO.

Easy To Read

Bennington, Vt.

. . . believe that this is an excellent publication . . . much more convenient to read and easier to cover than other publications . . . will be pleased to receive it in the future.

DR. C. E. IRION
Technical Director
BEN-MONT PAPERS, INC.

Valuable

Naugatuck, Conn.

Your new publication has just come to my attention and I was much impressed. In our particular phase of business, this type of information is most valuable and helpful . . . would appreciate being placed on your mailing list to receive future copies of R & E so that our entire Commercial Development Dept. as well as myself could benefit from reading it.

C. F. RUEBENSAAL
Commercial Development Mgr.
NAUGATUCK CHEMICAL
DIVISION U. S. RUBBER CO.

Good Coverage

Burlingame, Cal.

I've greatly enjoyed the first two issues . . . you have found an area of research activity which has not previously been well covered.

WARREN R. KETLER
BROADVIEW RESEARCH & DEVELOPMENT

Fills Need

Chicago, Ill.

. . . have had the privilege of reading R & E . . . feel this publication fills a very definite need in the engineering profession . . . would like to receive a copy each month.

L. D. HAGENBOOK
Chief Engineer
GOODMAN MFG. CO.

Send More Copies

Akron, Ohio

May I take this opportunity to commend your organization on the excellence of your choice of articles presented and of the manner in which they are prepared in R & E. The July-August issue was routed to approximately forty men of the section manager level in our Tire Development Department. They all found it interesting, informative and helpful. Would you please send us ten additional copies of your September issue. We are particularly interested in the article "How's Your Staff Efficiency?" . . .

W. J. LEE
Director Engineering Tire Development
THE GOODYEAR TIRE & RUBBER CO., INC.

Wide Distribution

Bristol, Conn.

. . . R & E has been widely distributed throughout the Product Engineering Department of New Departure. As a result, we feel that it will be of appreciable value to our organization and are . . . requesting you to continue sending it our way.

L. D. COBB
Manager, Research & Development
NEW DEPARTURE
DIVISION GENERAL MOTORS CORP.

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Whitehall, Mich.

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Development Contract Director
DEPARTMENT OF THE NAVY

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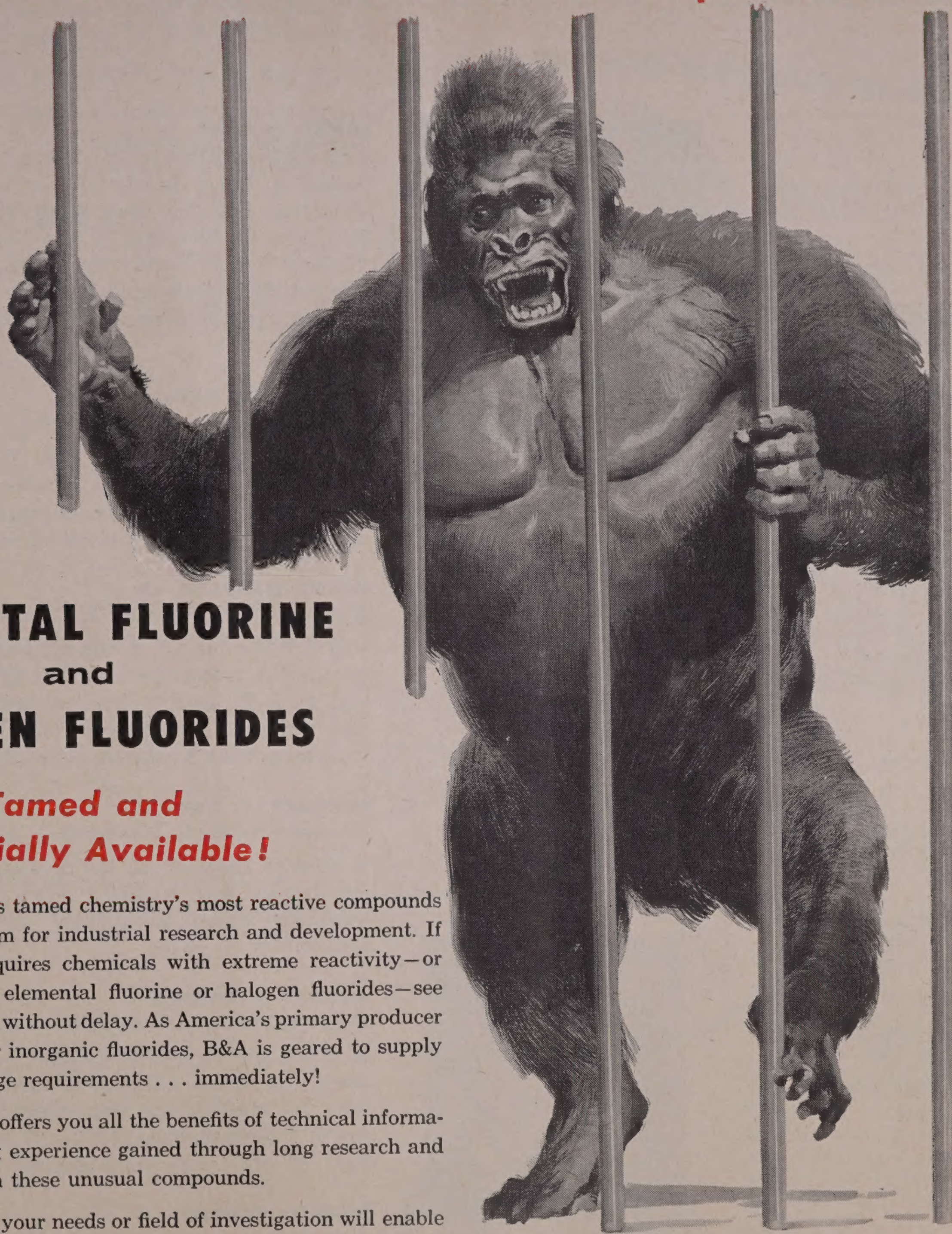

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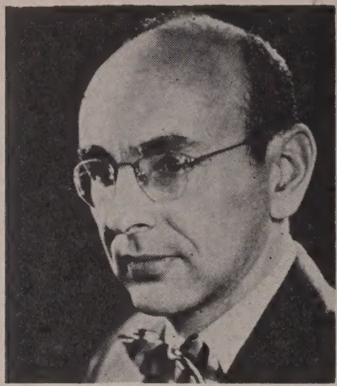
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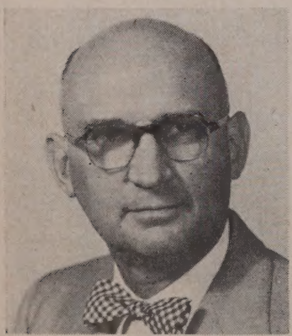
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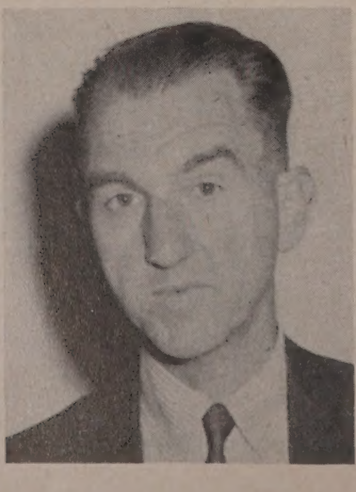
JOHN C. GREEN

JAMES A. LANE
Oak Ridge National Laboratory

James A. Lane, director of the Reactor Experimental Engineering Division, Oak Ridge National Laboratory (run by Union Carbide and Carbon Corp. for the USAEC), was recently honored with the Order of the British Empire. His article is abstracted from his paper released at the International Conference on the Peaceful Uses of Atomic Energy.

WILLIAM W. EATON

For his work in the Office of Scientific Research and Development during World War II William W. Eaton was awarded the President's Certificate of Merit. Since 1952 he has been an industrial consultant, specializing in management problems of industrial research.

ROGER WILLIAMS, JR.
Roger Williams Technical & Economic Services, Inc.

Roger Williams, Jr., heads his own rapidly growing chemical market research consulting firm. Educated at Amherst and M. I. T., he did chemical economic work for Du Pont and later was Associate Editor of "Chemical Engineering" magazine prior to starting his own firm.

HERBERT T. TIFFANY
Ordnance Research Laboratory

A former member of the Pennsylvania State University Accounting and Auditing Staff, Herbert T. Tiffany was appointed Chief Accountant at the Ordnance Research Laboratory in 1946.

ROBERT A. HUSSEY
Ordnance Research Laboratory

A graduate of Colby College (A.B.) and Pennsylvania State University (M.A.), Robert A. Hussey serves on the teaching staff of the Department of Industrial Engineering at Pennsylvania State University and is Business Manager of the Ordnance Research Laboratory.

RENATO CONTINI
New York University

As Research Coordinator in Bio-Mechanics and Industrial Engineering at NYU's College of Engineering, Renato Contini has been active in research in such areas as prosthetic devices, home construction and solar energy. He was formerly vice-president in charge of engineering, Hub Industries, Inc; and chief engineer, Langley Aircraft Corp.

JOHN C. GREEN
U. S. Department of Commerce

John C. Green received his B. S. degree from the U. S. Naval Academy and an L.L.B. from Georgetown University Law School, Washington, D. C. He began his government career in the U. S. Patent Office, transferred to the National Inventors Council shortly after its creation and now heads the Office of Technical Services.

RESEARCH & ENGINEERING

MAGAZINE OF RESEARCH AND DEVELOPMENT MANAGEMENT

VOL. 1—NO. 3—SECTION 1 OCTOBER-NOVEMBER 1955

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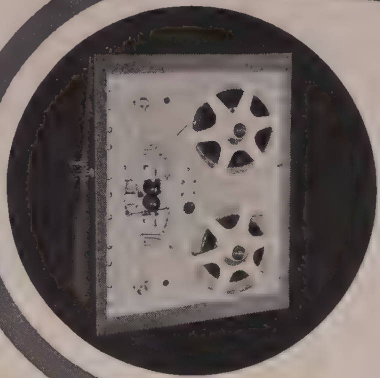

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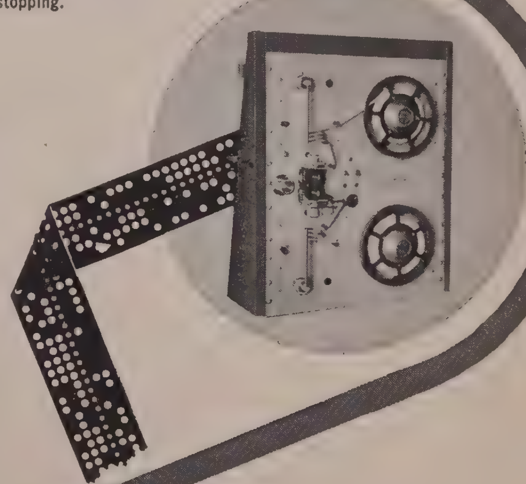

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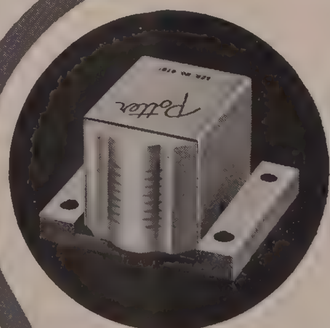

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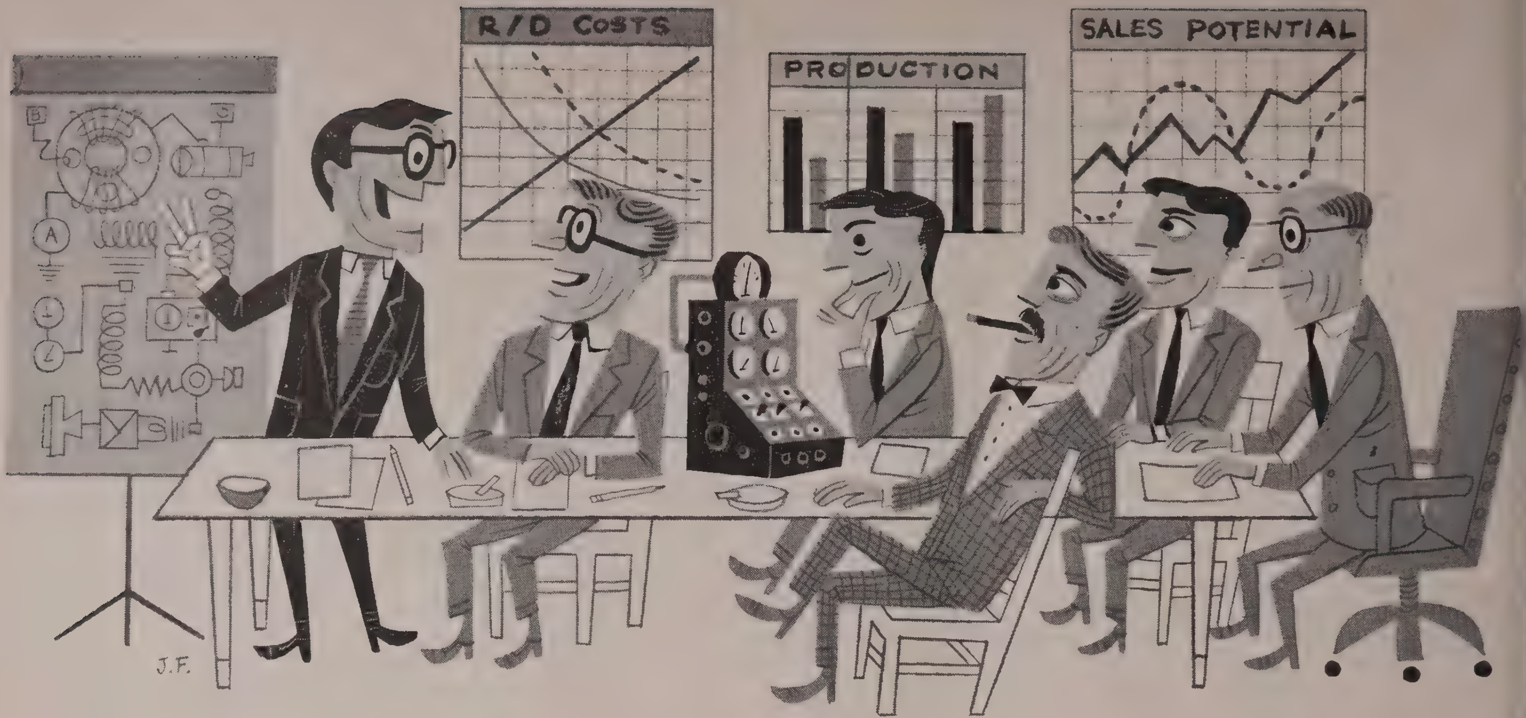

Turn Your Ideas Into Action

Have trouble putting those good ideas into company practice? And does your staff mumble when they try to get their proposals across to you? In either case, here are ten steps toward more effective presentation to the people that matter.

Luis J. A. Villalon — *Management Affairs Editor*

THE RESEARCH DEPARTMENT is the company's best incubator of new ideas to improve its processes, products and method of operation. Researchers and engineers have the skills, time and inquiring point of view necessary to create and nourish those flashes of originality that make all the difference between the modern company's success or failure. But most research and development men have a sneaking suspicion that a higher percentage of these bright ideas—dreamed up in their department—sound better than their batting average with top brass would indicate. Most everyone has experienced the frustration of seeing a brilliant innovation die because somehow it just couldn't be put across to a management that prides itself on practicality but suffers from acute astigmatism when it has to look much farther ahead than the edge of its desk.

The usual routine in these cases is for the researcher to roundly curse his superiors for lack of vision and failure to appreciate the tremendous engineering contribution to the company.

Maybe this is sometimes true—but even more often the failure lies in the Research and Development Department itself. The average research director is not by nature a salesman. His experience and training has been creative, and he's usually had little chance or incentive to develop the art of effective presentation to the extent that rising executives in other departments do.

Yet the research director who stops with the development of a good idea in his department has stopped ha- way in the task of performing a valuable service to I company—and to himself as well. The other half consi of getting the idea put into action. And the success a research executive's career may well depend upon single idea and how well it is put across.

The payoff comes for both the company and the in- vidual when other people understand the idea, accept and put it into effect. The scholar and the technical exp usually work up the good idea. A natural-born salesm can sell ideas or anything else. The effective resear director, however, has to be able to do both if he's goi to earn his salt.

You Don't Have to be Born with the Knack

Too many executives—especially those whose traini has been primarily technical—seem to be resigned to fact that their weakness in the salesmanship of ideas is j something to live with. That's not so. The art of effect presentation for executives—the ability to convey id effectively—is recognized by progressive companies as that can be acquired and built up. An increasing numb of companies are featuring this skill in their execut training courses for men already arrived as well as those on the way.

Other company presidents are forcing their departm heads to acquire this important skill by the simple dev

f refusing to listen to problems and insisting on carefully worked out, recommended solutions. The necessity f presenting problem solutions to the president of one f America's largest carpet manufacturing concerns in ıch complete fashion that he can decide yes or no withıt further investigation forces his department heads to schew the mumbling approach and come in with at least developed idea.

One of the large automotive corporations, realizing that n idea lost is the same as not having had one in the rst place, goes so far as to require that important sugestions be submitted in strip film form. They find that his saves the costly time of major executives.

This seemingly bulky process does two other things. It orces the suggestor to organize his material and, in rocess, tends to sharpen his thinking. It also puts the ompany spotlight on the executive who can't seem to hink in a straight line.

here Are Rules to the Game

Of course, very few organizations are large enough o go to such extremes, but that doesn't mean that the eed isn't as important. Fortunately there are other ways o achieve the same ends. Unfortunately they don't come ıt of books. There are libraries of volumes on selling ıst about everything else—products, public relations and mployee morale—but there aren't very many that purport o discuss selling ideas. The ten rules that follow are istilled from the experience of executives—research and therwise—who have been through the mill. Some were o effective in their presentation of ideas that they seemed o do it naturally—but disinterested analysis turned up heir tricks. Others have told R/E reporters how they've earned skills they considered completely foreign to their ersonality. These rules have double value for the research irector. He can put them to work himself in presenting is department's proposals to the rest of management, and e can pass them on to his subordinates so that they can resent their ideas more effectively and economically, timeise, to him.

1 Get it Down on Paper

This sounds obvious—but it's the single thing that is ammered hardest by management and consultants who ave studied this problem. They give a special meaning o their suggestion. They figure that writing the idea down orces you to recheck your analysis of the problem and hoice of solutions. If it's sound, it will stand being written own and may be improved in the process. On the other and, trying to put down a weak idea in logical order ends to show up the thin spots.

Preliminary attempts to create an outline of the proosal in language that will make sense to non-technicians nd non-specialists will help point up the factors that ave to be stressed in conveying the idea to the layman. Presentation of the technical idea poses special problems ecause of the need to express complicated concepts in rdinary business language. Nothing helps point up translaion needs more than a bit of pencil and paper work.

2 Analyze Your Approach

The first thing to expect from this paperwork is a larification of your real objective. Assume you're going into a staff meeting of your fellow executives plus the boss. You have a presentation to make. Is your immediate objective to "sell" them or "ask" them? Do you want to persuade the group that the course you suggest is the best one or the only one possible? Or do you honestly want to consult with them and get their advice and have them help decide what the best solution is?

The objective must determine how the presentation is made. Too often a research director goes into a meeting with an inconclusive discussion of a problem and asks general executives to make up their minds on matters on which they possess no basis for judgment. And then the research department wonders why it can't get a decision.

The very nature of the research department's work makes it likely that your presentation to outside department executives will have to be of the selling variety. You may want to consult them in an interim stage of your investigations—but when it comes to the end of the road, they expect that you, the expert, will have a definitive solution to put before them. Trying to duck with a series of alternatives that they can only vaguely understand runs the risk of having the whole project abandoned and your department branded as impractical and timewasting.

The art of effective presentation, however, works two ways. The ask 'em technique is particularly valuable when presenting a thought or a problem to your own staff. It is gradually outmoding the simple device of making a unilateral decision and informing your subordinates of it. Questionnaires to old-line, well-established companies indicate that their top men use the tell 'em method about 60% of the time, but in the younger organizations the proportion is only about 35%. Authoritarianism is giving way to persuasion in industry.

In the research department there is a particular premium on the persuasive approach. When you're dealing with temperamental technicians and free-thinking scientists, the leader must win support, not command it.

3 Tell How You Reached Your Answer

An important part of any presentation is a description of the route you traveled to reach the solution you advocate—after, of course, you have started off with a succinct description of the problem.

People are suspicious of the other fellow's intuition; they like to have it proved that he's thought it through. Even the false starts sometimes should be included, if for no other reason than to avoid other people's bringing up solutions already proved impractical or useless.

This kind of "chronological" approach sells the listener gradually by letting him follow your mind at work. Furthermore, it avoids the danger of springing on him points that seem obvious to you because of your special knowledge; after all, if he had as much technical knowledge as you do, he wouldn't need you as his research director. What may seem simple arithmetic to you may be higher mathematics to the man you're trying to sell.

A comprehensive recital of how your suggestion was derived will do more to enable your listeners to judge your idea in perspective. It will improve their own knowledge of your field and allow them to understand better your need of an adequate staff and facilities to traverse the long and tortuous route from problem to solution.

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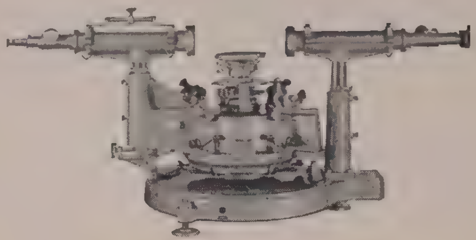

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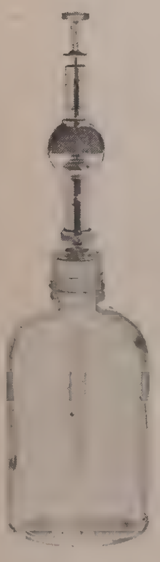

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4 Banish the Unknown

Often the toughest hurdle to overcome in suggestir a new approach is fear and suspicion of the unknow No top executive likes to admit this, because Americ industrial folklore endows him with the quality of fea less innovation. But very often he doesn't really have

He's asking himself who's going to do these new jol how difficult retraining his organization will be, how co veniently and well he can do what your proposal w require of him. Failure to explain how your proposal w work and how those involved can do the jobs proposed f them will at best delay their acceptance of the idea an at worst make them hunt for reasons to oppose it. Tl extra time spent in figuring out the detailed workings your proposal will usually pay off.

5 Appeal to Personal Interests

Theoretically everybody you have to sell this idea works only for the pure and simple good of the compan But we all know that this isn't quite true. People a motivated differently—some work for advancement, sor for security, some for prestige—and it is foolish ignore their personal considerations and special prejudic in selling your idea. The difference between ho-hum a proval and coats-off support often lies in your ability tie in with these special quirks.

For instance, suppose you know that the purchasir agent is a bug on penny pinching. Even if your idea i volves millions of dollars in capital expenditures, you m be able to get him to go along on the basis that the par will be cheaper once the revolution has been accomplishe Or take the vice-president in charge of sales. You'll was a lot of time if you try to sell him on the technic slickness of some innovation you've made. But he wou like to know what improvements that will make the pro uct work better he can show his customers.

Personal motivations are also important. Sometim your proposal will mean increased responsibility for given department head. Make sure he realizes it. Or tl idea may be one to make the boss look good in the i dustry; he is probably not averse to a little extra prestig

This section is not to suggest that a pound of hypocri can ease through an idea. When you examine your pr posal from this point of view—is it a sound one for tl company—you will be surprised how many departmen are benefited and how many people helped. You're doi them a real favor by letting them know about it in preser ing your proposal with due regard for their emotions well as their minds.

6 Add the Dramatic Touch

If a mystery writer started out by giving his solutic then listed the clues, and finally described the peo involved, he wouldn't sell many copies or hold his read

uch beyond the first or second paragraph. But if he vorks in the reverse direction, he can hold them from eginning to end. That's your clue for taking your presenta-ion out of the ordinary, dull and boring recital class hat has buried many good ideas. Present your problem, nalyze it, list alternative solutions and keep your own roposal a surprise until the last possible moment. This vay you'll have their ears until the end. Since they're ot sure what the key points will turn out to be, they'll ave to listen to all of them. (Never forget, however, hat even the mystery fan gets bored if the author thinks n terms of the length of "War and Peace"—the complete uspenseful approach does not mean the longwinded one).

One way to speed up the process—and to spark it up—s to use visual aids. The fact that the meeting of two ninds is often helped along by good graphic description s attested to by thousands of pencil marked table-cloths. Some people never think of using visual aids until they're vorking before a group so large that no one beyond the irst two rows can see the charts. A graphic presentation s just as useful with one hard-to-sell auditor as it is vith a group—and sometimes worth the trouble.

Don't be afraid of being over-dramatic. What you're eally offering is simplification. The flip-flop chart need ot be a product of some art director; a good black news-paper copy pencil and the freehand ability of the average eenager can make points just as readily. And any re-earch department has at least one chart maker who will robably be glad to be lured from his graph paper for a ew hours. It is a known fact that most technical chart nakers have a frustrated yen for cartooning that can be sed in selling ideas—as has been done in this article.

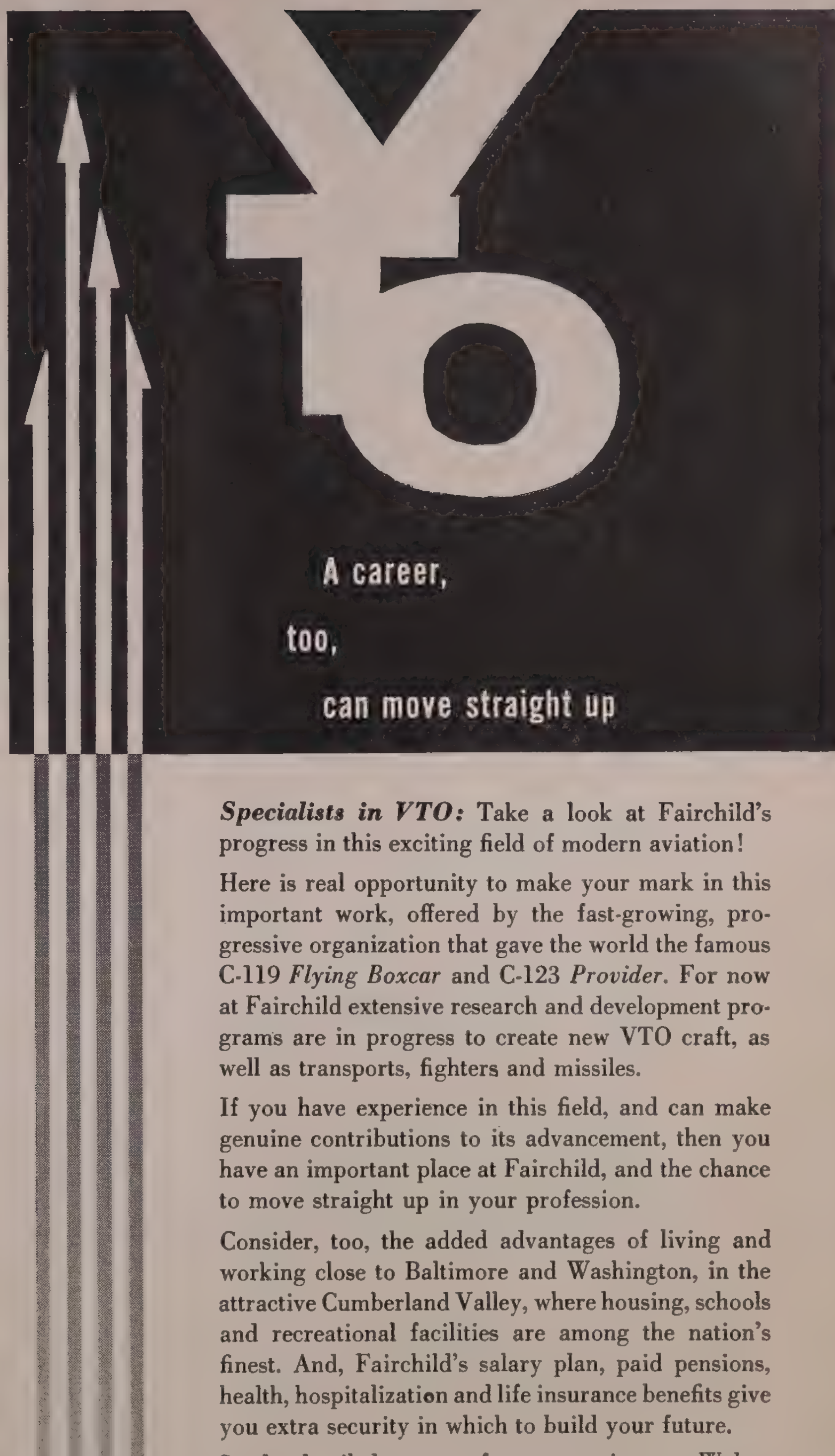
As a matter of fact a company as big as National Cash Register supplies big paper-pad, flip-flop charts to prac-ically all company executives. So does Standard Register.

Use of pictures, charts or even briefly worded outlines ot only dramatizes the idea, but tends to keep discussion n the main point. Conversation has a habit of veering ff into extraneous areas, but as long as the main theme s billboarded before the group, it's easy to return to the ubject.

7 Learn to Use Your Voice

Most of the scientifically minded get a good chuckle out of the success of the Dale Carnegie books and the various courses that have been offered in effective speaking and/or cultivating friends or other miscellaneous people. Let it be said here that they are not as foolish as they sometimes seem. Not every presentation is made verbally, but most have to be, at least partially. Learning the tricks of using your voice is worth a little extra time and effort, if only to fulfill your obligation of presenting your particular department as ably as possible.

There are many ways to improve this particular skill, and strangely enough most of them are foolproof. The average, untrained speaker just can't help but improve.



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Some companies have private speech classes for their executives on the grounds that it's a chore to listen to bad speakers. If you cringe at making a fool of yourself in front of other people, there a number of courses that use books and records very aptly to build your speaking effectiveness.

8 Junk the Gobbledegook

Scientifically trained people—i.e., most research directors—have a special affection for the language of their trade. The only trouble is that it doesn't make much sense to anyone else. Too often they get up in front of a group and purvey a brand of mumbo-jumbo English that hides their meaning instead of clarifying it. Very few colleagues or bosses will take the trouble to unwrap the layer of cotton wool that this automatically applies to one's meaning and personality.

Simplest solution is to talk naturally, after a special examination to eliminate gobbledegook and technical words.

9 Call in the Reserves

If worst comes to worst, never forget that there are ways other than formal presentations to get over an idea. There are a good many tricks that fall outside the interview or conference for getting a thought across. At one company, for instance, a research director was frustrated by the moss-grown policies of an elderly executive in selling a new process he considered necessary to keep the company competitive. He proceeded to publish his idea in a technical journal, and the flood of inquiries convinced the company of its possibilities.

In another case a research director abandoned a frontal attack when he saw that it wasn't getting an where, and proceeded to sell his idea to his opposite nu ber in other departments (see point 5). The boss g such a barrage of identical suggestions that he bought t proposal out of the impact of sheer quantity.

The late Albert Browning, vice-president in charge purchases of the Ford Motor Company, used a simple d vice to make his point. All over his office he display mounted before-and-after examples of minor changes car parts, listing the savings in cents per car and thousan of dollars per year. His subordinates and fellow exec tives got the idea.

10 Don't Let the Means Obscure the End

There is very little danger that the average resear director will turn into a professional presentation expert or, more commonly, a promoter—or, more rudely, a bun artist. But it is in order to point out that there is a dang in letting the mechanics of a presentation detract from t idea itself. But where the proposal is a sincere one, genuine accord with company interest, it is unlikely th the method of presentation will make it appear otherwis It is also unlikely that the slickest presentation will su ceed in selling a basically unsound proposal to any b the stupidest management.

These ten points aren't designed to sell blue sky, b they do recognize that no one buys the light under t bushel for illumination purposes. Like a dollar bill a idea is useless until it's put into circulation. You'll doing your company and yourself maximum service if y see that your department's ideas are given maximu currency.


You Can Install This Valve In
3
EASY
STEPS
A
Step 1. Slip the adapter nut and then sleeve over end of tubing. Be sure head of sleeve (A) is toward nut as shown.
Step 2. Insert tubing into valve as far as it will go.
Step 3. Tighten adapter nut. Note how sleeve (cut away for clearer view) grips tubing insuring a gas-tight seal.
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Chemical Market Research

Roger Williams, Jr.
Chemical Engineering Consultant

MOST APPLIED RESEARCH PROGRAMS contain two important objectives: The improvement of existing products and the development of new ones.

The uncovering of new knowledge and techniques that can improve the quality, production and distribution of the improved and new products.

Although few of us would disagree with these objectives, some of us would modify them.

Most of us think of accomplishing these objectives in laboratories and pilot plants —and to a great degree that is where the objectives are reached. Although we also realize the value of rational techniques in guiding research policies, most of us also know of cases where "hunch" played a part. But too little credit to and use of is given market research.

Just how does the research director know there is desire, active or latent, on the part of the public or industrial organizations to buy a product? The way to find out is called market research. Similarly when we consider more efficient distribution of existing products, we can use both market research and sales analysis.

What is Market Research?

Most people think of market research as a sort of Gallup poll of public opinion. They think of picking a test area for a new cereal, giving samples to a selected group of housewives, then interviewing the women on how well they liked it (and a thousand other questions and cross-questions), and subjecting the results to analysis on computer machines to determine the national thinking about the new cereal and how much might be sold.

That is market research all right—and it provides a valuable function, particularly to those firms selling in consumer markets. However, consider a different kind of market research—that on products sold to other industrial firms rather than directly to the public. The techniques and quality of the results are quite radically different from consumer market research, particularly when the market research is applied to chemical products.

The major difference between consumer and industrial market research is obviously, in the so-called "universe". For consumer market research we have to consider every American (and a lot of foreigners too) as potential buyers. The job is to determine, within reasonable accuracy limits, how many of 160-million-plus people will buy a certain product at different cost levels and considering known competitive materials. Unless a firm wants to throw away money, it can hardly contact more than a minor percentage of the total customers. The firm then has to rely on how "average" its sample is and compute mathematically the result; margins of possible error are also figured but too few people pay any attention to them, even technically-trained research directors. It is too easy to believe a figure like 42.2 million boxes of "Chewies" at 25¢ per box retail by 1960, even though the admitted accuracy is in the plus or minus 30% range at least.

Industrial market research is different. The "universe", the number of present and potential customers, is considerably smaller. Hence it is usually possible to contact personally a large majority of the total universe. Because of the smaller "total population", the need for fancy mathematical computations and analysis disappears. The breakdown of the current market and the forecast of the future market should be more accurate than in the case of consumer market studies.

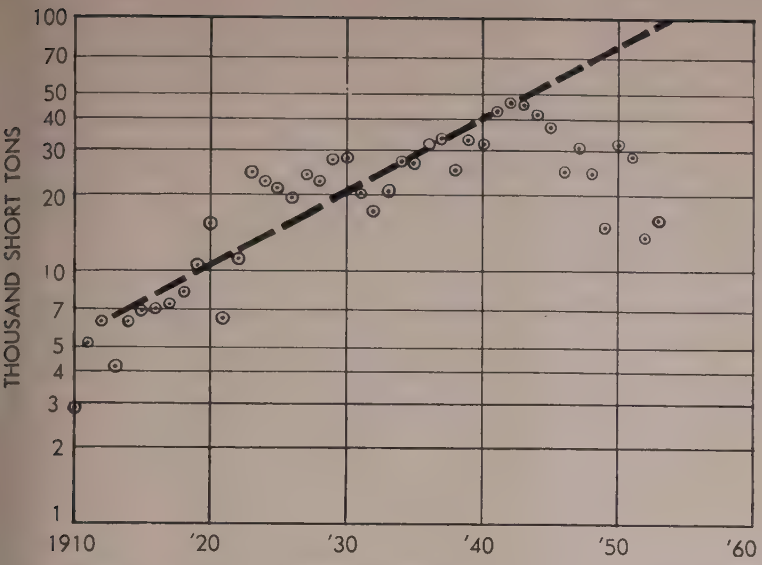
One factor should be made clear, however: the difference between market research, marketing research and sales analysis. To many research directors th[e] terms are synonymous; they should n[ot] be. Market research is a long-term look a[t] the future markets for a given produc[t]. It attempts to determine the future ma[r]kets generally by the consuming industrie[s] and develops the effects of differing price[s]. Market research generally is not concerne[d] with short-term changes in markets whic[h] can be caused by strikes or sudden scar[e] buying such as occurred at the start o[f] the Korean conflict. Marketing research, a[s] the name implies, involves the methods o[f] distribution for a product—distributor di[s]counts, effects of advertising, size of pac[k]age, etc. It is concerned with present an[d] future total markets only as these ma[r]keting variables affect it. Sales analysi[s] on the other hand, refers to knowledge o[f] current and short-term future markets. I[t] attempts to list every consumer, the amoun[t] purchased, and requirements next quarte[r] or next year.

Obviously marketing research and sale[s] analysis are of primary interest to sale[s] personnel and top management. Market re[-] search is of value to top management i[n] planning but primarily to research an[d] development planners.

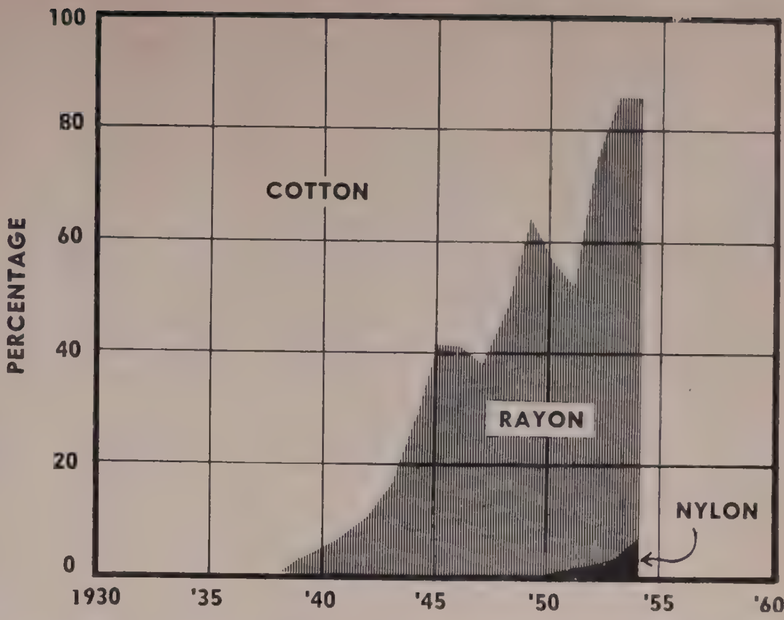
Case Histories

Suppose we take some cases of wha[t] market research has done, drawn from ou[r] own experiences, and then explain ho[w] market research is carried out.

Case 1—A company was considering pro[-] ducing chemical A. They had pilot plante[d] the process, had their own raw material[s]. They had carried out their own marke[t] research which indicated that present pro[-] ducers were operating at essential capacity and the market appeared to be growing. This company's management decided t[o] have a "checking" market research stud[y] done by an outside firm before they au[-]



Trend lines are one of a market researcher's tools but he does not rely on them too greatly. Look how far wrong he would have been using a long term trend (dashed line) on white arsenic. The newer organic chemical insecticides came along during World War II and have knocked out most of white arsenic's former markets.



A typical market research problem. In the last 15 years rayon has taken the lion's share of the tire cord market away from cotton. Now a newcomer, nylon, has entered the picture—black wedge at bottom right hand corner of the chart. The question for market research to answer is how far up the scale nylon can go and how fast?

thorized plant construction. The figures developed checked reasonably well with the ones the company's own personnel developed, but one small fact in addition came out. That was that the largest of the existing producers was substantially increasing capacity (without publically announcing it) and that this additional production would supply the market until at least 1960. Management decided not to build the plant.

Case 2—Research management of a chemical company read many of the published claims for the future of isocyanate foams, relatively new products. A market research study was undertaken not only to develop the magnitude of the probable future market but to determine the property requirements for each foam use. With this material in hand, research management then had a tool to determine whether or not to set up a research program on raw materials for this market.

Case 3—Chemical B is made in several grades. The company involved, however, made only one grade and that for captive consumption. They wondered whether or not they should start a research program for a process to make the other grades and enter the market. A market research study not only indicated the overall merchant market for the chemical but broke it down by grades and forecast future demand by each grade.

Three Phases of Market Research

How are these studies carried out? Almost all market research jobs fall into three phases. The first involves a literature study and planning the field contacts. The second phase is the field work—calls by chemists or chemical engineers trained in market research on purchasing agents, research directors, and similar personnel in companies known or believed to be using the chemical being studied. The number of these calls and their geographic distribution generally sets the magnitude of the study involved. For some chemical market research jobs the number may be as low as 25-30; on large studies the total may run over 300.

There are a number of types of field contacts to be made other than just consumers at present of the chemical being studied. Trade associations and publications are fruitful sources of information, as are Government agencies. Valuable also are what are called "secondary" users—best defined by an example. Suppose we were studying the present and future markets for the plastic polystyrene. One customer might be a large molder who produces refrigerator liners. In this case the "secondary" user is the refrigerator company, and it would probably be more fruitful to call on the latter than on the molder. In the case of a polystyrene market research study the number of field calls would break down somewhat as follows: trade associations, magazines, Government agencies, 15-25%; plastics manufacturers perhaps 5%; plastic fabricators, 15-25%; users and sellers of fabricated polystyrene items, 45-50%; and all other calls around 10%.

These field calls differ markedly from consumer market research also. For the latter, detailed questionnaires are usually drawn up, with the same questions asked in different ways as cross-checks. In chemical market research, questionnaires are seldom used. The field calls are more discussions between technically trained persons on a field of common interest.

The final phase of a chemical market research study, of course, is analysis of the information obtained and preparation of a report giving the study's findings.

There is another rather substantial difference between consumer and industrial market research, at least the chemical phase of the latter. Most consumer market research is conducted by firms who maintain consumer panels or interviewers scattered all over the country. Such market research is carried out by the producers or potential producers of the products being researched. In chemical market research, on the other hand, the majority of the work is done by the producers themselves. For example, less than 10% of the members of the Chemical Market Research Association work for consulting firms doing contract chemical market research.

This does not mean that contract market research in the chemical industry is not important; it is. And it is growing. There are a number of reasons why chemical companies "go outside" for market research studies, even chemical companies which have their own market research organization. One is anonymity—they do not want to tip off a potential competitor (who might also be a customer for another product) that they are looking at a given field. Another is that the consulting firm specializes in a given field. The contract market research may take less time in some cases, particularly where the consulting firm has previously surveyed a given field. The obvious example is where a company's own market research is over-loaded with work.

Regardless of whether industrial market research is done on contract or by a company's own personnel, two things seem apparent: (1) industrial market research is considerably different from consumer market research; and (2) industrial market research is a tool research management could use more widely.

x

Last summer the European Productivity Agency with the backing of the International Cooperation Administration sent a special two-man mission to Europe. The objective: to stimulate interest in the application of research to the problems of small and medium sized companies in various countries. Here's a special report from one member of the team on . . .

Industrial Research in Europe 1955

William W. Eaton
Industrial Consultant

DESPITE THE MANY EFFORTS to bring unification and standardization to a long divided Europe, it is still necessary to speak of individual countries when discussing industrial research. There are remarkable differences between the various countries—in attitude toward research, facilities, availability of trained personnel, methods of organization and the like. On the other hand, generalizations have their value, and it seems preferable to highlight some of these at the start before delineating some of the important exceptions.

• Today the large European companies are generally appreciative of the value of scientific research to their own operations and usually possess well equipped research laboratories and competent staffs. Relatively few small and medium sized firms, on the other hand, have research programs of their own. In many respects this status parallels the situation in our country 30 to 40 years ago.

• Compared to our method of operation a great deal more cooperative industrial research exists in Europe. Cooperation results among other things from a higher proportion of nationalized industries and from government sponsored research. It also reflects the fact that many companies are so small that a research laboratory in the usual sense is not possible financially. Hence a whole industry is constrained to pool its research resources in one place for the benefit of all the individual companies or to appeal to the government for help.

• The shortage of trained technical personnel for industrial research is even more acute in Europe than in this country. This condition is accentuated by the fact that the universities have not yet become fully awakened to the necessity for training students primarily for industrial research—men with broad, sound technical backgrounds coupled to a practical approach.

• Related to the above point and underlying the whole pattern of industrial research in Europe today is the lack of cooperation between university scientists and industry—reminiscent of conditions in our own country 40 years ago when a career in industrial research was considered by many to be just slightly beneath the dignity of a university scientist.

• Sponsored research in non-profit, non-government institutes such as our Mellon Institute, Battelle Memorial In-

stitute, Armour Research Foundation and others seems almost entirely lacking although we shall discuss some of the recent progress made in this direction. Also there is virtually no research being done by strictly commercial consulting laboratories.

• In Europe the concept of an expanding market is largely absent. There is very little real appreciation of the fact that proper consumer stimulation, new styling, new features, advertising programs and other techniques can substantially increase the market for products. Hence there is not the burning incentive we seem to have in the United States to improve products constantly and to develop new ones to maintain and improve competitive positions. Therefore, Europe has proportionately much less industrial research than we have compared to total products produced.

Fundamental Research

Conversely, Europe has a relatively large amount of fundamental or basic research carried on in large universities and government laboratories. Some of the reasons can be found in the early development of European universities. Since the time of the founding of the world's first university, the University of Bologna, Italy about the tenth century, university facilities in Europe have occupied a position of high prestige with considerable independence. For a long time the Universities of Bologna and Paris were the cultural centers of Europe and wielded great influence and power. In due course there developed similar influential faculties in other countries such as Germany, England and Austria. It was in these universities that most of the fundamentals of present day chemistry, mathematics, physics, electrical engineering and many other subjects were discovered and enunciated. Even up until approximately 1930 the majority opinion considered Europe the best place for grounding in the fundamental sciences.

The momentum thus gained over many centuries in attacking the basic problems of nature persists to this day even though the United States now paces many branches of science and engineering. The net result is that today the European universities are still doing good fundamental research—the kind of basic work turned out in the past by people such as J. J. Thomson, Lord Rutherford and Enrico Fermi.

It is true that in many cases individual European professors act as consultants to industry but usually only on specific problems. Little fundamental work is done by the companies themselves which is in sharp contrast with the large amount of such work carried on by some of our leading United States companies.

Cooperative Research

With some notable exceptions cooperative research is the "favorite" technique in Europe at the moment. This method of pooling research funds from companies of all sizes in one industry has probably reached its highest state of development in England but is widely practiced in many other European countries. In some instances the cooperative research is entirely voluntary; in others it is a matter of law with contributions exacted from all companies within an industry according to size. Legislated cooperation is particularly prevalent in France where many industries are nationalized.

A typical example is the Ironworks Research Institute near Paris (I.R.S.I.D.) which carries out research for the iron and steel industry. This facility is an excellently equipped and staffed research laboratory with an able administration board reporting to a governmental board. We have no parallel to it in this country inasmuch as our Iron and Steel Institute is a private voluntary organization and sponsors work in various locations rather than at a central laboratory.

Italy is an exception in the area of cooperative research partially because individual manufacturers tend to be somewhat reticent about sharing their problems with other companies in the same industry. Here is an incident that typifies a prevalent attitude. The director of one of the many well-equipped government Experimental Stations in Italy specializing in applied research for one particular industry became discouraged because so few companies sought the help with their problems to which they were entitled. Yet he felt certain that many of these firms badly needed the technical information which his laboratory could furnish. So he placed some blind advertisements stating that if any company in this particular industry needed technical assistance,

application could be made anonymously; the consulting help would be forthcoming and free of charge. To his surprise over sixty replies were received. This illustrates why cooperative research is just "not in the cards" for Italy at this time.

One of the most interesting illustrations of recent progress in cooperative research is the establishment of the Central Institute for Industrial Research in Oslo, Norway. This is an institute for both cooperative and sponsored research established in 1950 by the Norwegian Council for Scientific and Industrial Research, a government organization. Many of the buildings are still under construction at this writing, but considerable progress has already been made on many research projects through the use of temporary quarters in the nearby university, with which excellent relations are maintained. In its finished form at least ten cooperative research institutes will occupy space in the new buildings, and there is ample provision for future expansion. Norway, although not a highly industrial country and with only three and one-half million population, has thus in a few short years built the nucleus of what will soon be an industrial research center of high quality and wide scope.

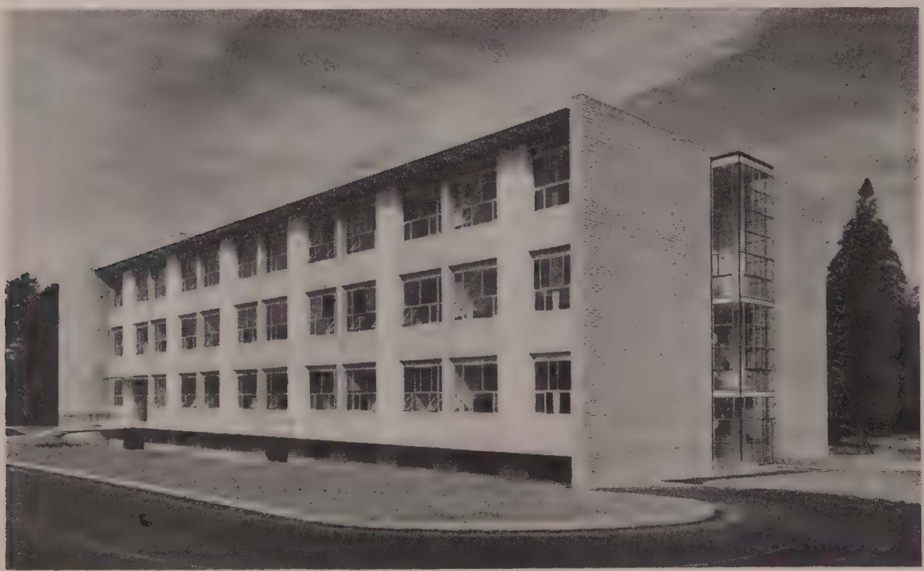
Government Sponsored Research

A much larger proportion of applied industrial research is government sponsored in Europe than in our own country. Probably the outstanding example of a comprehensive government research program directed at the problems of industry is the Department of Scientific and Industrial Research (D.S.I.R.) in England. With a long and distinguished history of accomplishments, this agency operates through a large number of separate laboratories devoted to particular industries. There are also in England many other governmental laboratories doing applied research for industry.

When one adds these governmental efforts to the many cooperative research activities in England and other individual research laboratories of large companies, the result is a substantial total applied research program in England, even excluding military and nuclear energy research. The latest available compilation shows the British non-military research effort to be about one-half of one percent of the gross national product, which is of the order of magnitude, percentagewise, of our own non-military research.

In France, Italy and many other Western European countries virtually all the applied research done outside large companies is government sponsored in some way or other. Even many of the cooperative research institutes are either wholly or partially financed by the government. For example, in France applied research is carried out at a large number of state laboratories and laboratories of nationalized enterprises. Also the National Center of Scientific Research sponsors applied research in universities as well as in its own laboratories. In Belgium the most important organization for applied research bears the rather imposing title "Institute for the Encouragement of Scientific Research in Industry and Agriculture". This agency was legislated into existence in 1945 and has a record of vigorous growth and expansion since that time. It operates largely through subsidies to various institutions, both academic and industrial. The scope of the program is very comprehensive. In Austria the government applied research program has been necessarily slow in getting under way because of serious war damage and occupational difficulties. However, within the past three years a great deal of progress has been made in establishing centralized research facilities in Vienna at what is known as the "Arsenal", and some of the leading university professors in Austria have directed research toward practical goals.

Thus each country has established its own particular way of undertaking industrial and applied research, and the systems of organization vary in accordance with the many factors of difference between the countries. To attempt to discuss organizational and other details for each country would cover too much ground and would probably interest only a limited few. However, a short description of applied research methods and modes of operation in one specific country may be of interest in pointing up factors which are common to all countries. For this purpose a good example is Italy, where considerable progress is being made in applied and industrial research.



Geneva lab, 40,000 square feet, contains facilities for research in various aspects of physics, chemistry and metallurgy. Staff is mainly Swiss, complemented by scientists from four European countries.

Frankfurt lab, 160,000 square feet, contains foundry and metal-working facilities for heavy metallurgical research plus ceramics, chemistry and physics labs.

Applied Research in Italy

In Italy there are a large number of relatively small government research centers and institutes. The National Research Council sponsors the research centers, principally at universities, and the various government ministries have "Experimental Stations" in various fields of interest.

These stations are in general well equipped and staffed by able scientists. They have one unique feature in that in addition to the general program of work paid for by the government the stations can undertake additional research when sponsored and paid for by a specific company. Such work is separate from the rest of the program, and the results are kept confidential. This feature is very similar to our system of sponsored work at privately endowed research institutes in the United States. Unfortunately, few firms in Italy utilize these opportunities.

The applied research carried on in Italian universities can be considered in effect as "Government sponsored" since all the universities are state owned and operated. The professors are free, however, to undertake consulting research work for industries, and a relatively few do add such activities to the normal academic routine.

Serious handicaps to the full flowering of applied industrial research in Italy are the lack of full cooperation between industry and the universities and a reluctance on the part of many companies to come—individually or collectively—to the Experimental Stations for help. The result is the rather tragic consequence that these government centers, with the best of staff and equipment, are not being utilized to anything like their fullest advantage. This same observation applies with equal force to the utilization of the university research scientists in Italy. For example, there is nothing in Italy (or other European countries either for that matter) to compare with such institutions in our country as the Division of Industrial Cooperation at M.I.T. or the Ohio State Research Foundation of Ohio State University.

Italy has other problems in connection with applied industrial research which are in the process of correction at this moment. One is the fact that there is too wide a gap between the training of engineers at the very practical "technical institutes", on the one hand, and the highly theoretical and broad arts training of the university scientists on the other. In fact the graduates of the technical institutes, which are actually much more than trade schools, are not even allowed to go on to a university curriculum. This understandably cuts down severely on the type of trained technical manpower which is the backbone of industrial and applied research.

Another problem peculiar to Italy is a fiscal one; manufacturing firms are taxed not on income, but on gross sales. Not only does this lead to a widespread attempt to keep all sales and financial data confidential, but it means that the normal costs of research cannot be deducted as expense, thus reducing the incentive to spend money on research. Fortunately, a very definite remedial movement is under way.

The Italian National Committee on Productivity is very alert to the importance of research in industry and has followed an active program of indoctrinating industrial managers in how to undertake research and use the results profitably.

Sponsored Research Institutes

Just as we can say that the cooperative research movement in Europe is "in vogue" today, we can make a similar statement about the United States with regard to research in endowed institutes such as Mellon Institute, Battelle Memorial Institute and many others. The many advantages offered, particularly to small and medium sized companies, by such institutes have prompted many people to ask, "Why can't the same system be utilized effectively in Europe?" The answer is that it has only been tried to a very limited extent and there are very few data to prove that it will or won't work. The most significant efforts to establish this type of research facility in Europe have been those of the Battelle Memorial Institute which has since 1952 established two branches in Europe; one at Geneva, Switzerland; the other, at Frankfurt, Germany.

Battelle's policy has been to staff these laboratories with nationals of the respective countries; a small group of Americans in an advisory capacity helped the laboratories become established. The Geneva staff now employs 95, while the Frankfurt operation has grown to 270 employees. Both groups are housed in new buildings of modern design.

Two years of operation have answered many of the questions originally raised about the possibilities for this kind of system in Europe. The success of the two laboratories in their operations to date indicates that contract research probably can be sold as a profitable investment to European industrial firms even though it is new and untested to them. Also the indications are that the research team approach to technical problems can be as productive and valuable in Europe as it has been proved to be in the United States.

While the initial success of these two laboratories is significant, keep in mind that there are unfortunately many factors in Europe tending to work against this type of operation. These include secrecy tendencies among small and medium sized manufacturers, lack of capital to endow necessary facilities and prevalence of "competing" government and cooperative research groups.

Organization for European Economic Cooperation

No discussion of industrial research in Europe would be complete without mention of the Organization for European Economic Cooperation, an organization of 17 European countries, and its sub-agency, the European Productivity Agency. The Applied Research Division of these groups has carried out during the past three years a positive program aimed at pointing up the value of industrial research in improving general productivity. Such efforts have been carried on with the necessary backing of our foreign aid program now under the International Cooperation Administration. The activities have involved such things as the dispatching of special European missions to this country and conversely the sponsorship of many visits by American industrial scientists to Europe. Also some very valuable meetings and symposia have been arranged which have provided opportunities for the exchange of ideas.

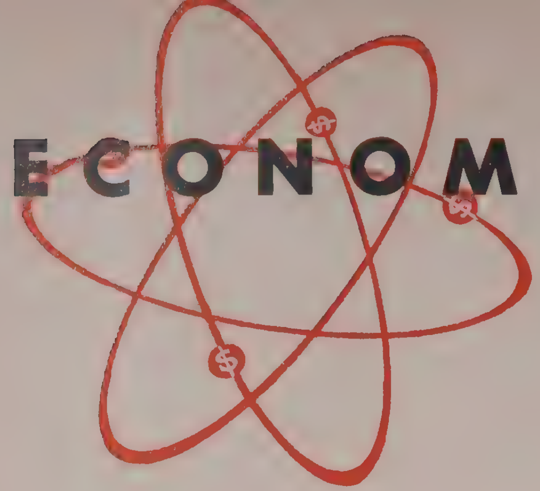
Summarizing impressions of industrial research in Europe at this time inevitably leads to comparisons with the United States. Certainly there seems to be an awareness in Europe that the vast investment in applied research in our country has been a most important factor in increasing our productivity and raising our standard of living. With this realization has also come a definite determination by both government and industry to increase both the amount and quality of industrial research in Europe. Such policies have already taken form in a number of ways. For example, careful study of United States research techniques; greater interest in research by small and medium sized companies; increase of government budgets for research; establishment of cooperative and other research centers.

Yet there are many handicaps to a rapid acceleration of Europe's research efforts for industry. The gap between universities and industry is too wide to be bridged easily. And such a simple factor as limited funds will place a distressingly low ceiling on research efforts in many countries. Also the lack of full appreciation of how research can expand markets will no doubt continue to curb the incentive to conduct research.

For our part we can profit considerably by a critical examination of the research situation in Europe at this time. Their persistent attention to fundamental research should make us pause to review the wisdom of our own relatively reduced efforts along these lines. We can undoubtedly gain too by studying some of the advantages of Europe's widely used cooperative research technique as a means of avoiding duplication of research by companies in the same industry. Although it is clear that the cooperative idea would not be a satisfactory substitute for our individual company system, it is probable that a suitable combination of the two would improve our overall research efficiency at least in some industries.

In any event we should not fail to keep ourselves informed on applied research trends in Europe. And from a strictly humanitarian standpoint we can only hope that with a reasonably extended period of peace Europe's industry and governments will have time to translate their research as we have into a higher standard of living and a better life for all. ✖

ECONOMICS OF NUCLEA



Here are the answers to:

What are the technical problems in the generation of nuclear power?

What are the promising solutions?

What will the outlook be when these solutions succeed?

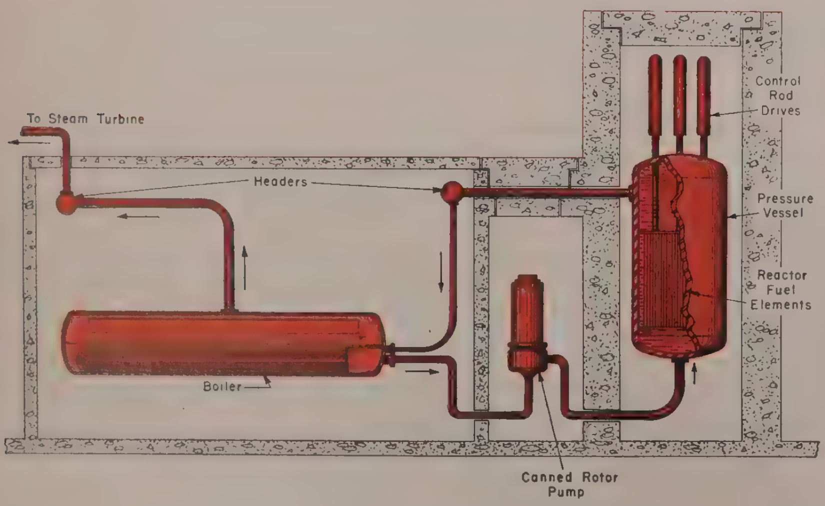
James A. Lane
Oak Ridge National Laboratories

IN 1975, the estimated production of electricity in th United States will amount to 1400 billion (1.4×10^{12}) kil owatt hours. Most of this electricity will be supplied b burning coal, oil and gas; a smaller portion from nuclea plants. Just what this portion will be depends on how suc cessful the present reactor development program is in solv ing the many technical problems which affect nuclear powe economics. At this time one can only define what these prob lems are, what is being done to solve them and what th outlook is if these solutions are successful. Since the abov estimate of the increase in the electric power system ove the next 20 years constitutes a potential nuclear plant in vestment of about 30,000 millions of dollars, the reward for a successful reactor development program may be grea The technical achievements of the U. S. reactor progran thus far realized give added incentive for pushing ahea with the development of civilian power reactors at maxi mum speed.

Two approaches to the development of large-scale powe reactor technology are underway in the U. S.: the AEC 5 year civilian power reactor program; and industries' powe demonstration reactor proposals. A review of these pro grams from the standpoint of their relation to the possibi ity of achieving economic nuclear power is worthwhile.

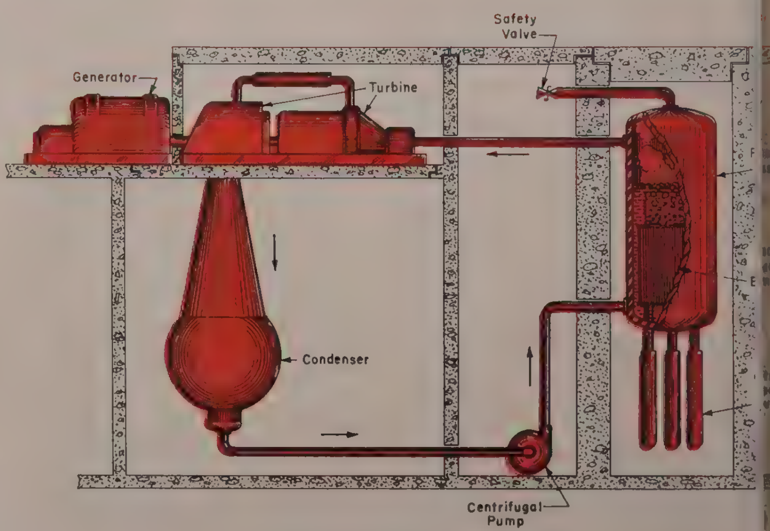
Reactor Development Programs

The AEC 5-Year Civilian Power Reactor Program (Tabl I) announced last year involves the construction of one fu



PRESSURIZED WATER REACTOR SYSTEM
(Forced circulation H_2O or D_2O)

Fig. 1—In the pressurized water reactor either heavy water or ordinary water can be used as the coolant and moderator with appropriate adjustment of spacing and enrichments of fuel elements. (Westinghouse reactor uses H_2O). Water is pumped between solid fuel rods in the reactor core and then to a heat exchanger where steam is produced to drive a turbine.



BOILING WATER REACTOR SYSTEM

Fig. 2—In the boiling water reactor (also using either H_2O or D_2O steam is produced directly by allowing boiling to occur within t reactor core. This method of heat removal eliminates the heat e changer, has corresponding higher thermal efficiencies and reduc size of pumps and other equipment. Offsetting these advantages a required higher fuel enrichment due to presence of steam in the co and the necessity for enclosing turbine and condenser within a shie due to radioactivity of the water.

POWER

scale pressurized water reactor power plant and intermediate or small scale prototypes of other reactors which show promise of low cost nuclear power. Approximately 200 million dollars will be required to support this program over the next five years. The building of these prototype plants will not only provide information leading to reduced costs but will also permit a more realistic evaluation of the applicability of nuclear energy for larger scale power production.

A more venturesome reactor program, the construction of full scale nuclear plants, is being considered by various industrial groups in the U. S. (Table II). Except for the Consolidated Edison reactor, which would be built entirely with private funds, the proposals involve some help from the government—waiving of AEC charges for the loan of nuclear fuel and fertile material for up to seven years, support of AEC labs in R/D work without charge and advance payment by the AEC for the technical and economic information to be gained. If all of these proposals are acted upon favorably, the installed nuclear plant capacity in the U. S. will amount to about 800,000 kw of electricity by 1960.

TABLE I

AEC 5-YEAR CIVILIAN POWER REACTOR PROGRAM

REACTOR TYPE	AEC LABORATORY	POWER, MW HEAT	POWER, MW ELEC.	COST*	DATE READY
Pressurized Water	Westinghouse	264	60	$85 x 10^6	1957
Boiling Water	Argonne	20	5	$17 x 10^6	1956
Sodium Graphite	No. American	20	..	$10 x 10^6	1956
Fast Breeder	Argonne	62.5	15	$40 x 10^6	1958
Homogeneous Reactor Test	Oak Ridge	5	1	$3 x 10^6	1956
Homogeneous Thorium Breeder	Oak Ridge	65	16	$44 x 10^6	1959-7

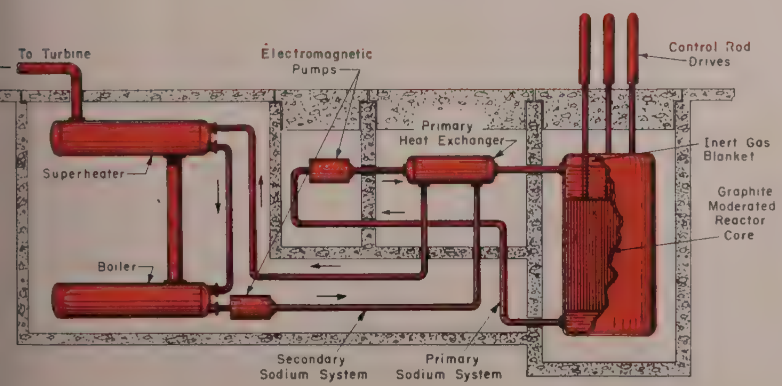
*Includes some research and development

TABLE II

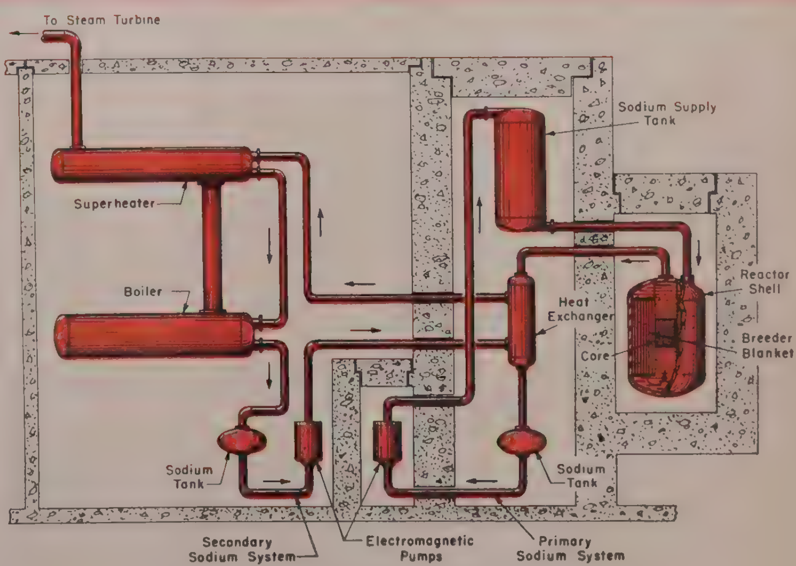
INDUSTRIAL POWER DEMONSTRATION REACTOR PROPOSALS

REACTOR TYPE	SPONSOR	POWER MW-ELEC.	COST	DATE READY
Pressurized Water	Yankee Atomic Electric	100	$24 x 10^6	1957
Boiling Water	Commonwealth Edison (Nuclear Power Group)	180	$45 x 10^6	1960
Sodium Graphite	Consumers Public Power District	75	$24 x 10^6	1959
Fast Breeder	Detroit Edison	100	$45 x 10^6	1958
Pressurized Water	Consol. Edison*	236	$55 x 10^6	1959

*License requested for construction with private capital



SODIUM GRAPHITE REACTOR SYSTEM



SODIUM COOLED FAST REACTOR SYSTEM

Fig. 3—Sodium graphite reactor takes advantage of high temperatures and high thermal efficiencies to be gained through use of liquid sodium as the coolant and graphite as the moderator. Here the primary sodium coolant circulates between solid fuel elements in the reactor and then through a heat exchanger where heat is transferred to a secondary sodium system. In contrast to the primary sodium, which becomes radioactive, the secondary sodium can be circulated outside of the shield through a steam generator.

Fig. 4—Fast breeder reactor consists of an unmoderated core, fueled with plutonium containing uranium-238 and surrounded by a uranium-238 blanket. Primary sodium is used to cool both core and blanket in conjunction with a secondary sodium system. Advantage of the fast breeder is the high breeding gain possible with fast neutrons in the Pu-239, U-238 system, due to lower parasitic capture of neutrons by Pu-239 itself. On the other hand, fast reactors require a large amount of nuclear fuel with corresponding high inventory charges.

The Nuclear Plant Steam System (Turbogenerator Plant)

Most of the emphasis of the reactor experimental program thus far has been associated with the problem of finding reactor systems operating for long periods at the high temperatures necessary for efficient power production. The most promising approaches use sodium at temperatures of 900°F to 1100°F and pressures of about 100 pounds per square inch absolute or water at 540°F to 630°F under pressures up to 2000 psia. The resulting steam temperatures range from 400°F to 1000°F. Although such a range of temperatures has a considerable effect on the net thermal efficiency of the power recovery plant, the corresponding capital costs of this portion of the nuclear plant do not vary as widely. In the case of the water cooled reactors, turbogenerator plant costs vary from \$115 per kw to \$125 per kw, and for the sodium cooled reactors from \$97 per kw to \$100 per kw. The significance of this aspect of nuclear power economics is that differences in power costs in various types of nuclear plants and in conventional plants will be due primarily to the construction costs and operating costs of the boiler plant or reactor rather than to the turbogenerator plant.

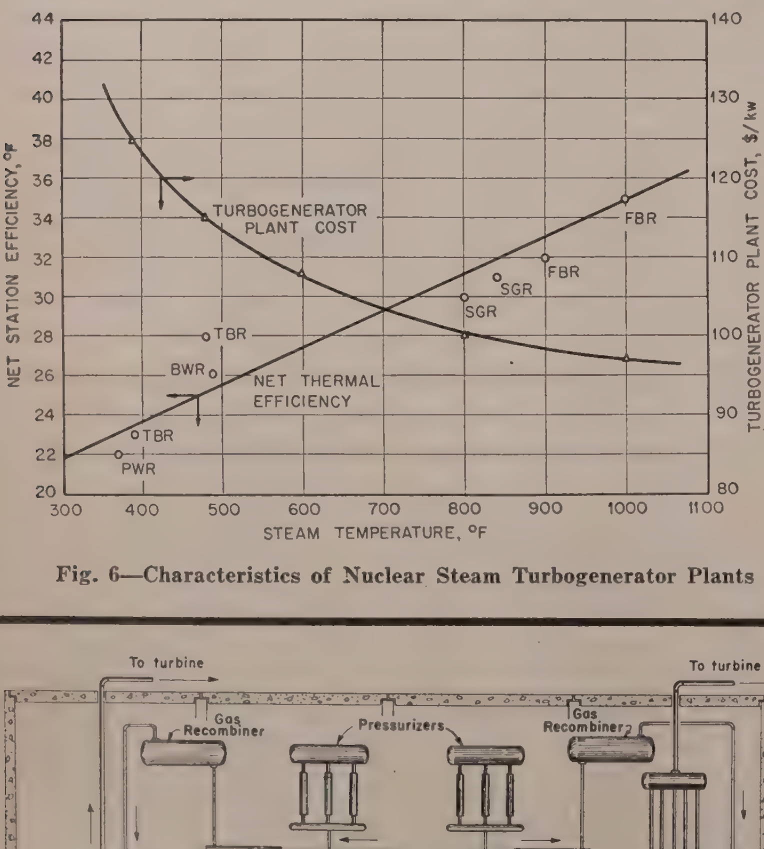


Fig. 6—Characteristics of Nuclear Steam Turbogenerator Plants

Review of Estimated Capital Costs

Available data on the cost of electricity from large scale nuclear plants are all based on paper studies. In most cases estimated power costs are more strongly affected by various non-technical assumptions such as plant write-off, inventory charges and load factor rather than by factors related to reactor technology. Since the selection of non-technical assumptions reflects the degree of optimism or pessimism of those making the estimate, such projected costs have no real significance. However, the fact that the optimists outweigh the pessimists and most predictions indicate a promising outlook for competitive nuclear power is very encouraging. As a matter of fact, most people are asking "When will we have competitive nuclear power?" rather than "Will we have competitive nuclear power?". Estimated capital costs of various large scale nuclear power plants summarized in Table III vary from \$183 per kw capability to \$450 per kw. Note that some of these costs represent firm bids for actual projected plants. Corresponding power cost estimates range from 4 mills/kwh to 10 mills/kwh.

Specifications for Competitive Nuclear Power

The AEC has estimated the amounts of energy from steam generating capacity required in 1975 as a function of the cost of power as shown in Table IV. The potential market up to 1975 for nuclear plants which produce power at 10 mills per kwh is 300 million dollars, increasing to 3800 million dollars at costs below 7 mills per kwh and 25,000 million dollars at 4 mills per kwh. Thus it is important to determine what conditions must be met for nuclear plants to achieve power costs in these ranges. The main problem is not one of determining how much the nuclear plant will cost but in estimating (a) how long it will last (b) operating and maintenance costs and (c) net fuel cost after adding charges due to fuel inventories, fuel burn-up and fuel reprocessing and subtracting the value of new fissionable material in the reactor. Since there is no actual operating experience with large scale nuclear power reactor available at the present time, most nuclear power cost estimates are greatly affected by the degree of optimism used in selecting the reactor amortization period, the load factor and the operating and maintenance costs. This is evident in the following paragraphs which define the conditions and assump-

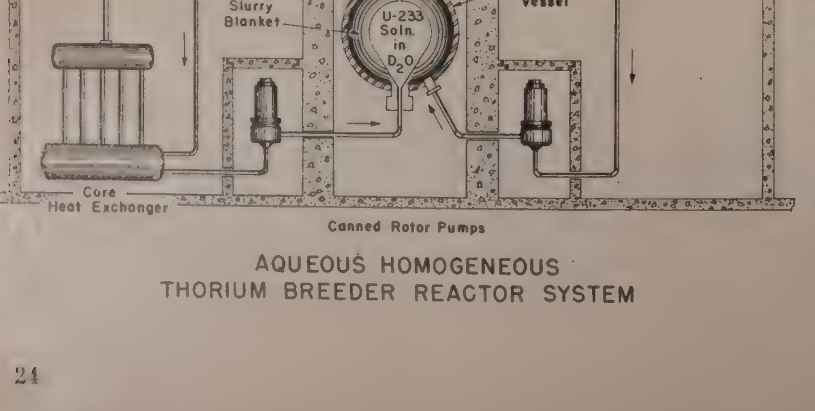


Fig. 5—Aqueous homogeneous reactor uses dilute solution of U-233 in D_2O flowing through an inner core vessel in which the major portion of the heat is generated. This core is surrounded by a larger pressure vessel through which a suspension of ThO_2 in D_2O is circulated, the thorium serving as a breeding blanket. Both core solution and blanket suspension are circulated through heat exchanges where steam is generated. Advantage of using a fluid fuel and blanket is primarily that of having simpler chemical processing systems and thus lower fuel processing costs. Both the uranium solutions and thorium suspensions, however, are somewhat corrosive, highly radioactive and in general require very special fuel circulating and heat removal systems. One of the major problems in handling aqueous fuel solutions is caused by decomposition of D_2O in the presence of radiation. The explosive deuterium—oxygen gas mixture thus formed must be separated from the circulating liquid stream and recombined before being injected back into the system. The pressurizers shown serve to maintain a constant volume and prevent boiling in the circulating liquid.

tions necessary to obtain power costs at 4 mills per kwh, 7 mills per kwh and 10 mills per kwh respectively.

4-Mill Power Costs: To obtain power costs of 4 mills per kwh in nuclear plants, it will be necessary to achieve favorable operating conditions such as a 90% load factor and maintenance costs as low as 0.5 mills per kwh. Under these conditions, at lowest estimated nuclear plant costs of $180 per kw capability, net fuel costs as defined above of 0.10 mill per kwh must be realized.

7-Mill Power Costs: At average capital costs and less optimistic operating conditions (i.e., 80% load factor and 1.0 mill per kwh operating and maintenance costs), nuclear power costs in the range of 7 mills per kwh will be reached with net fuel costs between 0.5 and 1.2 mills per kwh.

10-Mill Power Costs: Nuclear power costs of 10 mills per kwh can be projected on the basis of a relatively conservative set of operating conditions such as a 70% load factor and maintenance costs up to 1.2 mills per kwh. At estimated capital costs of $290 per kwh net fuel costs of 1.7 mills per kwh would be sufficient. A more complete breakdown of estimated capital costs and required net fuel costs to achieve economic power in water-cooled reactors and sodium-cooled reactors, respectively, are shown in Table V.

Nuclear Fuel Systems

Although enriched uranium-235 has a very high energy content (20 x 10^6 kwh of heat per kg) in the estimated price range of $15 to $30 per gram, it is a no cheaper fuel than coal. Since the most attractive aspect of nuclear energy is the possibility of achieving fuel costs considerably below that for coal, all nuclear fuel systems considered for large scale power production involve breeding or regenerative systems. Here uranium-238 or thorium-232 is placed in the reactor core or around the core as a blanket whereby through the capture of neutrons new nuclear fuel is produced. Extent of the capture depends on how well the fertile uranium or thorium competes with the other materials in the reactor system after allowing for losses due to neutron leakage.

Continual striving for higher neutron economy, that is, more efficient neutron absorption in fertile material, represents the major portion of that part of the civilian reactor development program aimed at economic power. This program includes development of the technology of low neutron absorbing structural materials such as zirconium, use of special moderating materials such as D_2O and consideration of special problems associated with fast reactors. As far as economic factors are concerned, it is necessary only to consider neutron economy in a general way, such as that measured by the conversion ratio of the system. This is usually defined as the atoms of new fuel produced in fertile material per atom of fuel burned. Depending on the particular reactor design, the conversion ratio may vary over a wide range. However, for the particular types of reactors being considered, the maximum conversion ratio will be of the order of 1.0 for the regenerative reactors, about 1.2 for the aqueous thorium breeder, and about 1.6 for the fast breeder.

TABLE III
ESTIMATED CAPITAL COSTS OF NUCLEAR POWER PLANTS

REACTOR TYPE	COMPANY OR STUDY GROUP	Power Level MW-ELEC.	CAPITAL COST* $/kw
D_2O moderated and cooled	Commonwealth Edison (Nuclear Power Group)	234	352
H_2O moderated and cooled	Commonwealth Edison (Nuclear Power Group)	273	236
D_2O moderated, H_2O cooled	Bechtel, PG & E	101	365
H_2O moderated and cooled	Fluor Corporation	200	183
Graphite moderated, H_2O cooled	General Electric	700	249
H_2O moderated and cooled	Yankee Atomic Electric	100	240**
H_2O moderated	Consolidated Edison	236	233**
Boiling H_2O	General Electric	300	226
Boiling H_2O	Nuclear Power Group	180	250**
Sodium Graphite	Monsanto	150	291
Sodium Graphite	No. American Aviation	150	243
Sodium Graphite	Consumers Public Power District of Nebraska	75	323**
Fast Breeder	California Research & Development	173	269
Fast Breeder	Detroit Edison	100	450**
Aqueous Homogeneous	Foster Wheeler-Pioneer Service	100	256
Aqueous Homogeneous	Nuclear Power Group	180	240

*Excluding fuel inventories in reactor and processing plants.
**Power Demonstration Reactors—1955

TABLE IV
PROJECTED ADDITIONS TO U. S. ELECTRIC POWER SYSTEM
(Excluding Internal Combustion Plants 1955-1975)

GENERATING COST MILLS/KWH	CUMULATIVE % OF TOTAL	KWH X 10^9	MW CAPACITY AT 60% LOAD	CUMULATIVE CAPITAL COST
10	1	9	1700	$300 x 10^6
8	4	36	6800	$1200 x 10^6
7	14	118	22000	$3800 x 10^6
6	39	340	65000	$11000 x 10^6
5	67	580	110000	$19000 x 10^6
4	85	740	140000	$25000 x 10^6
3	98	855	163000	$28000 x 10^6
2	100	874	166000	$29000 x 10^6

TABLE V
REQUIRED NET FUEL COSTS FOR COMPETITIVE NUCLEAR POWER

	$/kw		mills/kwh		$/kw		mills/kw		$/kw		mills/kwh	
	H_2O	NA	H_2O	NA	H_2O	NA	H_2O	NA	H_2O	NA	H_2O	NA
Boiler Plant (Reactor)	60	130	1.1	2.5	95	155	2.0	3.3	130	180	3.2	4.4
Turbogenerator Plant	120	100	2.3	1.9	130	105	2.8	2.2	150	110	3.7	2.7
Operation & Maintenance			0.5	0.5			1.0	1.0			1.2	1.2
Required Net Fuel Costs (Inventory & Processing Costs, By-product Credits)			0.10	–0.9			1.2	0.5			1.9	1.7
TOTAL			4.0	4.0			7.0	7.0			10.0	10.0

Fuel Costs in Regenerative Reactors

The regenerative reactors, with natural or enriched uranium are closely tied to an isotope separation plant such as the gaseous diffusion plant. This serves to provide slightly enriched uranium as feed to the reactor (if necessary) and to re-enrich the depleted fuel. The fuel costs in these reactors depend essentially on the cost of slightly enriched uranium, the irradiation time, the value of depleted uranium as feed to the isotope plant, the various chemical processing and fabrication costs, and, finally, the value of plutonium in the depleted fuel. Taking these factors in turn, the first problem is the question of the cost of slightly enriched uranium. No official data on such costs have yet been released. However, it is possible to estimate the value of slightly enriched uranium relative to the value of highly enriched uranium from the equations which characterize the behavior of an ideal isotope separation plant. Hypothetical costs of slightly enriched uranium so obtained are relative to, and therefore only as good as, the assumed cost of enriched uranium, but do provide a basis for comparing fuel costs in regenerative reactors using different enrichments.

With regard to costs for other steps in the processing cycle, such as costs due to conversion of uranium from one form to another, the situation is also complicated by the lack of reliable unclassified cost data. Here, however, since such costs do not greatly influence total costs, one can arbitrarily assume that all chemical conversion steps will be of the order of $4 per kg based on industrial experience with similar operations. Other uranium processing costs are $9 per kg for machining uranium, $7 per kg of uranium for addition of a cladding material such as zirconium and $13 per kg of uranium for recovery and decontamination. The cost for natural uranium metal has been taken to be $40 per kg. As a first approximation, the amount of plutonium in the depleted fuel, neglecting higher isotopes, may be estimated from the thermal neutron cross sections of U-238, U-235 and Pu-239 and the initial conversion ratio in the reactor. The Pu-239 growth shown in Figure 9 has been calculated as a function of irradiation time, expressed as megawatt days of heat per ton of uranium (1 ton = 910 kg), for a conversion ratio of 1.0. The depletion of U-235 shown has been estimated in a similar fashion. All higher isotopes of plutonium and uranium have been neglected. Figure 9 can be used to estimate the Pu-239 credit for various irradiation times and enrichments.

These data, though crude, can be used to estimate the net fuel costs in regenerative reactors. The results shown in Tables VI and VII have been calculated on the assumption that highly enriched U-235 and Pu-239 have the same value and are $15 per gram and $30 per gram, respectively. Other assumptions include 10,000 MWD/T irradiation, $40 per kg uranium, 80% load factor and a 4% fuel inventory charge.

Effect of Exposure Time On Fuel Costs

The fuel costs shown in Tables VI and VII have assumed an irradiation time of 10,000 MWD/T. It is of interest to observe the effect of burn-up on net fuel costs. The same estimated range of $15 to $30 per gram of uranium-235 is used to make this comparison with an equivalent credit for the Pu-239 produced in the reactor and recovered from the spent fuel elements. The results shown in Figure 10 indicate that under the assumed conditions in reactors fueled with uranium containing 2% by weight of U-235, irradiation times greater than 10,000 MWD/T (megawatt days per ton) are necessary to achieve fuel costs less than 0.5 mill per kwh. The required irradiation time in reactors fueled with 1% U-235, however, is only 5000 MWD/T. In natural uranium fueled systems, it is seen that fuel costs actually start to increase on long irradiation. This is because Pu-239 in the assumed range of $15 and $30 per gram has a slightly higher value than the U-235 in the $40 per kg uranium, and with long irradiation too much Pu-239 is consumed in the reactor. With plutonium at a lower value than natural uranium, there would be less incentive to remove the plutonium and sell it.

Thus it is seen that in regenerative reactors which achieve fuel burn-up times up to 10,000 MWD/T, net fuel costs will vary from —0.7 mills/kwh to 1.4 mills per kwh, depending on the assumed value of highly enriched uranium and plutonium and the degree of enrichment. In regenerative reactors fueled with uranium containing more than 2% U-235, net fuel costs are not likely to be less than about 1.3 mills per kwh. In natural uranium reactors, on the other hand, net fuel costs between —0.7 mills per kwh and 0.2 mills per kwh may be possible. In this case the inventory charges for D_2O should be added. At a heat removal rate of 10 kw per liter and an estimated cost of $28 per lb ($61 per kg), the D_2O would add about 0.35 mills per kwh to the fuel cost of a natural uranium-D_2O moderated and cooled reactor.

Fuel Costs in Fast Breeders

By definition breeder reactors are those which "produce as much or more fuel than they burn". Thus in these systems there is no cost due to the consumption of fuel in the reactor although there may be a credit for fuel produced. The fuel and fertile material can either be mixed and used in a single region core or the fuel can be concentrated in the center of the reactor and surrounded by the fertile material. For reasons of both neutron economy and fuel inventory, most fast breeder designs favor the two region approach, although it is often desirable to have some

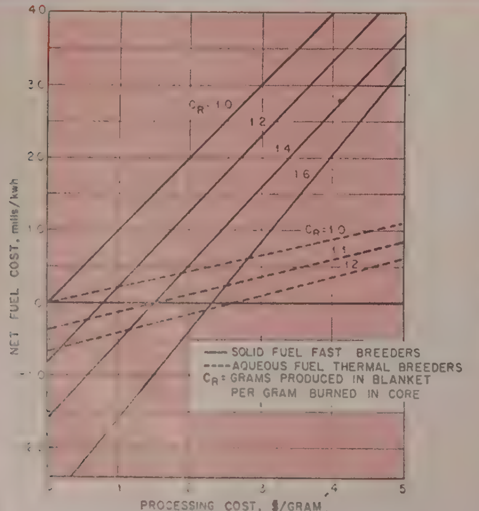


Fig. 13—Fuel Cost in Breeder Reactors

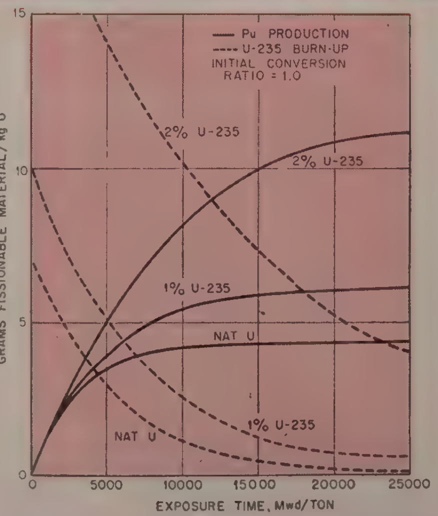


Fig. 9—U-235 Depletion and Pu-239 Growth in Regenerative Reactors

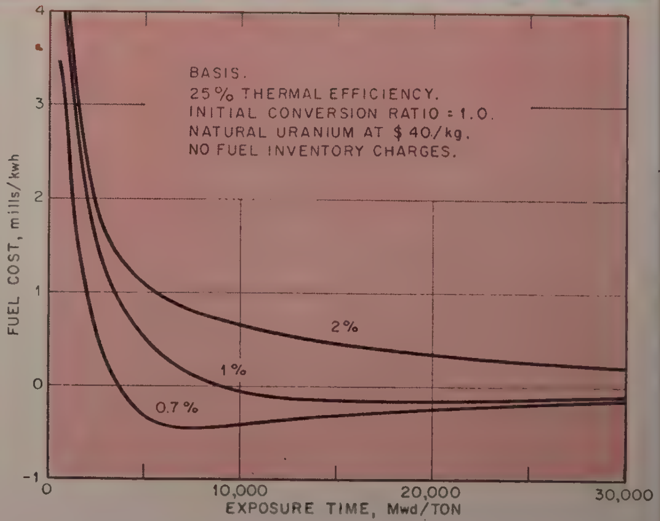


Fig. 10—Fuel Cost in Regenerative Reactors

U-238 in the inner core as well as the blanket. A typical system would utilize a mixture of 10% Pu-239 and 90% U-238 in the fuel region, and about 1% Pu-239 and 99% U-238 in the blanket region. The latter concentration is fixed by the balance of blanket inventory costs and blanket processing costs. In determining processing costs, $22 per kg for fabricating core elements and $11 per kg for fabricating blanket elements are arbitrarily allowed and a burn-up of 20% of the Pu in the core per cycle assumed. Inventory costs are based on heat removal rates of 100 kw heat/kg U in the core and 15 kw heat/kg U in the blanket, with Pu-239 credited the same range of values as previously. The credit for plutonium produced as a by-product has been calculated using this same range and assuming a conversion ratio of 1.6 (breeding gain =0.6). The two power costs are based on the high and low costs of recovery and decontamination of fuel and blanket elements of $37 per kg U and $13 per kg U, respectively.

Fuel Costs in Aqueous Thorium Breeders

As in the case of the fast breeder system, most designs of adequate homogeneous thorium breeder reactors utilize an enriched core surrounded by a fertile blanket. In typical large-scale reactors of this type, the fuel in the core consists of a solution of about 3 grams of U-233 (as sulfate) per liter D_2O and the blanket a suspension of 1000 grams ThO_2 per liter D_2O. The U-233 in the blanket is allowed to build up to an equilibrium value of about 3 grams per liter before starting processing and recovery. The U-233 itself is obtained by feeding the core initially with enriched U-235.

Processing steps for the homogeneous reactor include removal of fission products which act as undesirable neutron poisons in the core solution and decontamination of thorium and recovery of the U-233 produced in the blanket. Taking the same costs for processing thorium as for uranium, $13 per kg, gives a cost per gram of U-233 processed of about $4. Processing costs have been calculated on this basis, assuming a burn-up of 75% of the U-233 in the core per cycle. This latter figure is determined from a balance of processing costs and neutron losses due to fission product poisons.

The importance of high fractional burn-up in the core is illustrated in Figure 13, which gives the fuel costs in both fast and homogeneous breeders as a function of cost of processing and conversion ratio. The lesser slope of the thermal breeder graphs is due to the 75% burn-up for these reactors compared to the 20% burn-up assumed for the fast breeders. However, the higher conversion ratio of fast breeders tends to compensate for this disadvantage.

Outlook for Low Cost Nuclear Power

On the basis of a cost of natural uranium of $40 per kg and a credit of from $15 to $30 per gram of fissionable material produced in the reactor, the possibility of achieving nuclear power costs in the neighborhood of 4 to 5 mills per kwh seems good. This can be done in a pressurized water reactor plant fueled with natural uranium and cooled and moderated with heavy water. Such a plant would have to cost no more than $200 per kw capability excluding the cost of D_2O. The plant would have to operate at a 19% load factor assuming 15% annual fixed charges on plant and 4% on fuel inventories. An irradiation time of fuel elements of from 5000 MWD/T to 6000 MWD/T is required.

Power costs at 5 mills or less might also be achieved in an ordinary water cooled and moderated reactor fueled with 1% U-235. With plant costs similar to those given above, irradiation times of the order of 10,000 MWD/T would be required.

With regard to the breeder reactors, power costs of 4 to 5 mills per kwh are possible at fuel processing costs of $1 per gram or less. Under these conditions, the cost of a power plant utilizing a fast breeder with a conversion ratio of 1.6 could be as high as $270 per kw with a 90% load factor. With similar processing costs and a conversion ratio of 1.15, an aqueous homogeneous nuclear power plant would have to cost $200 or less per kw capability to produce power at less than 5 mills per kwh.

With regard to the sodium cooled-graphite moderated regenerative reactor, no reasonable combination of fuel costs and published capital costs can be now projected which yields electrical power less than 5 mills per kwh. However, the possibility of getting into the 6-7 mills per kwh range seems very good with this system. Here the required conditions would be reached in a plant costing $240 per kw capability, fueled with 2% enriched uranium at irradiation times of 10,000 MWD/T.

Taking all available economic and technical information at its face value, it is evident that the outlook for the large-scale nuclear power in the U.S. is very promising. If anticipated nuclear plant costs and operation conditions such as long life of equipment, high load factor and efficient fuel utilization can be realized, such plants will produce electricity at prices well below the average for conventional fuels. There is good indication that these necessary advances will be achieved in the next five to ten years through vigorous reactor development and nuclear power plant construction program now underway. ✖

TABLE VI

NET FUEL COSTS IN REGENERATIVE FACTORS

(U-235 valued at $15 per gram)

	mills per kwh		
U-235 enrichment =	0.71%	1.0%	2.0%
Natural uranium feed	0.61	0.96	2.16
Isotope enrichment	0	0.18	1.06
Conversion UF_6 to metal	0	0.07	0.07
Fuel fabrication	0.13	0.13	0.13
Fuel cladding	0.10	0.10	0.10
Chemical processing spent fuel	0.20	0.20	0.20
	1.04	1.64	3.72
Fuel inventory charges	0.13	0.21	0.53
	1.17	1.85	4.25
Pu-239 credit	—.95	—1.23	—1.86
Value of depleted uranium	0	0	1.10
NET FUEL COST	0.22	0.62	1.29

TABLE VII

NET FUEL COSTS IN REGENERATIVE FACTORS

(U-235 valued at $30 per gram)

	mills per kwh		
U-235 enrichment =	0.7%	1.0%	2.0%
Natural uranium feed	0.61	1.08	2.68
Isotope enrichment	0	0.39	2.45
Conversion UF_6 to metal	0	0.07	0.07
Fuel fabrication	0.13	0.13	0.13
Fuel cladding	0.10	0.10	0.10
Chemical processing spent fuel	0.20	0.20	0.20
	1.04	1.97	5.63
Fuel inventory charges	0.13	0.26	0.81
	1.17	2.23	6.44
Pu-239 credit	—1.87	—2.46	—3.70
Value of depleted uranium	0	0	—1.39
NET FUEL COST	—.70	—.23	1.35

Are You Using
Government Research?

John C. Green
Director, Office of Technical Services
U. S. Department of Commerce

ONE OF THE MOST spectacular developments in American industry during the past 15 years has been the tremendous surge of interest in research. Every company that can afford it is to some degree in the research business, and this year over four billion dollars will be spent on research in over 4,300 laboratories, as contrasted to about 500 millions in less than half as many labs 15 years ago.

A significant fact about this large volume of research, a fact that may not be generally realized, is that over half of the money will be spent by the Federal Government, some of it in Government laboratories but more in industrial and institutional laboratories working under Government contract.

With the Government so heavily engaged in research, most of it for national defense, some of the best scientific talent and facilities of the nation are working for the Government; and some of the most significant achievements of American scientists this year can be expected from Government research. Realizing the immense importance of these achievements to the advancement of American industry, the Government has in effect a policy whereby as much information as can reasonably be released without endangering our national security will be made available to those who can use it. This means that the enormous wealth of information that is not directly concerned with secret weapons will not bear a security label but will be turned over to business as unclassified or declassified material.

What Can You Get From OTS?

The Office of Technical Services, U. S. Department of Commerce, is the agency principally concerned with getting this information to industry where it can be incorporated into new product development and used for improvement of technological processes.

OTS was set up in business at the end of the war with Germany in 1945 to perform a special service to industry, a service growing out of the fruits of victory. As allied forces swept over Germany, the industrial and scientific secrets that had made the Nazi war machine the powerful and almost invincible force it was began to come to light. Valuable scientific and technical documents were uncovered everywhere, from the I. G. Farben industries to the lesser elements of German production. Immediately, American and British teams of technologists were sent into the defeated nation where they ferreted out and protected these research papers in order that the data contained in them could be used for technological advancement in the Allied countries. To catalog, store, produce copies and disseminate the multitude of documents, the Office of Technical Services was created.

The office now collects research reports from the Army, Navy, Air Force, Atomic Energy Commission, National Advisory Committee for Aeronautics and many other Government agencies. The enormous volume of research done by or for these agencies probes into almost every field of industrial interest including metals, chemicals, ceramics, plastics, electronics, foods, fuels, instruments, textiles, leather, rubber, geology and mineralogy.

Out of this research come many developments that can be used in private industry in the engineering of new products, processes and technological improvements—developments ranging from the vulcanization of rubber with gamma radiation to better methods of machining titanium, from new packaging possibilities with polyethylene bottles to the application of automation in the factory, from waterproofing shoes with plastics to the production of new adhesives. OTS has gathered more than 250,000 of these reports, and just recently the Atomic Energy Commission turned over to the agency its entire collection of several thousand unclassified reports of industrial interest.

Reports Aid Product Development

Many companies, large and small, have actually developed new products using the fruits of Government research. For instance, one company recently used OTS research reports on magnesium fabrication to design an item for the military with a two-to-one reduction in weight. Another developed a marketable polyester spray for exterior coatings. Still another used Government technical research to step up its entire engineering program and is now ready to market several new products.

A new product is not usually to be picked up, all ready for production, out of one of these reports; some further engineering is necessary, but the groundwork for new product development is often contained in a report. In many cases companies have avoided costly research of their own by checking on what the Government has done, obtaining all reports on a particular project, then picking up where the Government research leaves off. Many of these represent research endeavors beyond the capacity of even some of the large companies, but when a problem must be solved for national defense, such as how to handle hydrogen contamination of titanium, the Government must spend whatever is necessary toward a solution. This often brings a new material into much earlier use by private industry than is normally anticipated.

When these reports are received by OTS, they are evalu-

ated by technologists and about 300 of them are abstracted in a monthly OTS publication, **U. S. Government Research Reports,** which is handled on a subscription basis by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at $6 a year. The reports of wide interest are selected for reprinting and sale by OTS at the cost of printing and handling. Prices of large reports are sometimes as much as eight or ten dollars, but the average is around $1.50 for a report that gives the complete research procedures, conclusions and recommendations growing out of a project that has cost the Government many thousands of dollars. The remainder of the 300 or so reports, which are important but of more limited interest, are turned over by OTS to the Library of Congress where they may be studied in the Library Annex or obtained in microfilm or photocopy reproductions. Examples of the monthly stock of reports selected for sale by OTS, may be found in the Research Report sections of R/E.

OTS also publishes a monthly **Technical Reports Newsletter** ($1 a year from the Superintendent of Documents) which contains abstracts of 15 or more of the best reports received each month, with particular emphasis on reports usable by small businesses. For special research studies more than 300 **Catalogs of Technical Reports** (10 to 25 cents a copy) have been prepared on a wide variety of subjects. A single catalog lists all reports in the OTS collection, going back in some cases as far as the German research documents, on such subjects as electroplating, transistors, adhesives, cellulose and industrial diamonds. A list of these catalogs can be obtained by writing to OTS.

This agency has also published seven inexpensive volumes describing 4,300 Government-owned inventions available for license to private firms on a non-exclusive royalty-free basis. In this **Patent Abstract Series** many companies have found a new item for manufacture. The seven volumes are Instrumentation; Chemical Products and Processes; Food Products and Processes; Metal Processes and Apparatus; Machinery and Transportation Equipment; Electrical and Electronic Apparatus; Ordnance; and Ceramic, Paper, Rubber, Textile, Wood and Other Products and Processes.

To provide individual service to companies requiring the latest information on a particular product or process, such as new methods of precision casting or recent developments in synthetic lubricants, OTS maintains a small staff of technologists who conduct a "Question and Answer" service. Use of this service can be made by writing to OTS or by calling on one of the Department of Commerce field offices.

Other Agencies Can Help You

Also a part of OTS is the National Investors Council. Companies interested in directing some of their research efforts toward the development of military materials should request NIC's publication, **Technical Problems Affecting National Defense** and its supplements. This list is basically prepared to acquaint industry, science and the public with some of the problems currently confronting scientific and technical personnel in the military establishments; however, it may give new direction to ideas or partially developed items which may have been shelved because a company could foresee no commercial market and was unaware of the military needs. It can also suggest new products, materials and processes for commercial development.

Two other agencies in the Department of Commerce should be mentioned: the Patent Office and the National Bureau of Standards. The Patent Office's weekly publication, the **Official Gazette,** contains a list of patents available for licensing or sale. When an investor or a firm holding patent assignments wishes to sell or license them, they use the **Official Gazette** to publish the information.

The work of the National Bureau of Standards is devoted to the development of devices and processes to serve special needs of the Government. In some instances such devices have commercial applications such as NBS's recent electronic flow-meter, magnetic fluid clutch, ceramic coatings for high temperature alloys and printed electronic circuits. Such products are available for commercial use on a non-exclusive, royalty-free basis. Information can be obtained by writing to the agency. NBS publishes **Technical News Bulletin** which each month reviews new NBS product and process developments.

While this article has been devoted almost exclusively to the Office of Technical Services, there are other important Government sources of research information in specialized fields. Many of the Departments, such as the Department of Agriculture and the Department of the Interior, sponsor specialized research. These Departments should be checked, as well as the Superintendent of Documents, who is charged with the collection and sale of most of the regularly published Government documents, and the Armed Services Technical Information Agency of the Department of Defense, which furnishes information to contractors of the DOD. In addition, an informative little booklet which lists many Government sources of information on new product development can be obtained from the Superintendent Documents. This booklet is **Developing & Selling New Products,** price 40 cents. It was published by the Department of Commerce and the Small Business Administration.

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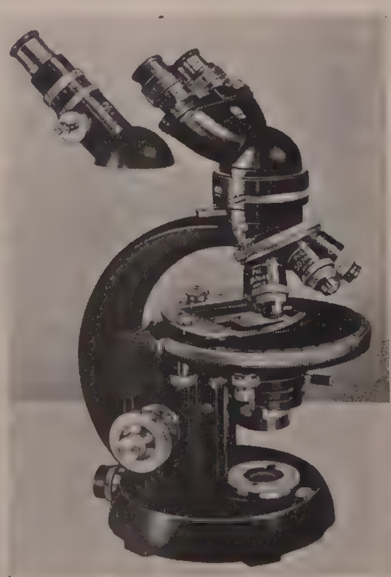

The famed Zeiss Winkel Polarizing microscopes are now available for research and laboratory requirements in both binocular and monocular types, both featuring the inclined-tube system for ease of operation.

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Medical Engineering
New Area for Research and Development

Renato Contini
Research Coordinator
New York University College of Engineering

THE TWO GREAT APPLIED SCIENCES of the present are medicine and engineering. Both are directed toward improving mankind's condition on this earth; both have scored remarkable progress in the last half century. Yet medicine and engineering have joined forces only sporadically and haphazardly. Too often they work independently toward the same ends but with different means. The result is not only a duplication of time and effort but also neglected opportunities for registering even greater impact on man's well being.

Certainly the professions engage one another's minds and talents when necessity demands it—the development of the mechanical heart required a maximum interchange of skills. But a broad potential area of systematic and continuing cooperation for mutual benefit lies unexploited.

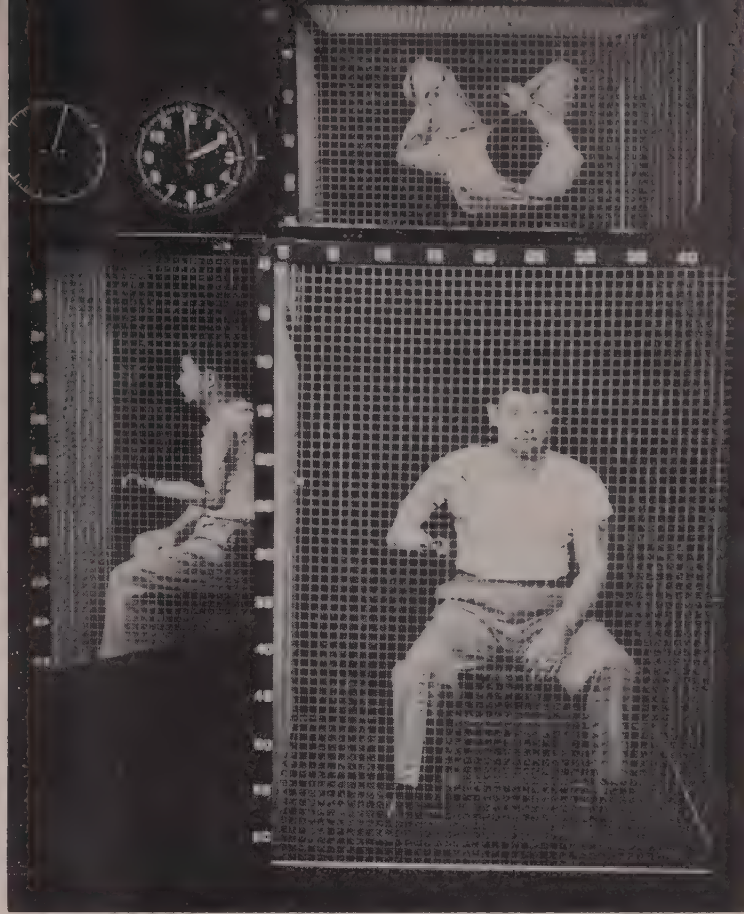
The development of a lasting and fundamental pool of engineering and medical resources must be fostered on several levels beginning with the formal education of practitioners of both sciences and continuing in professional associations. For the engineer the challenge exists on a day-to-day basis, not merely to wait to serve the physician in creating tools for the diagnosis, therapy and cure of human ailments, but actively to seek and engage in research in new areas which only the engineer is equipped to explore.

Why have medicine and engineering historically remained relatively isolated from one another? Perhaps the chief reason lies in the growing accumulation—and at the same time fragmentation—of scientific knowledge. Only 500 years ago Leonardo da Vinci could speak with authority on a gamut of disciplines: anatomy and physiology, engineering and the physical sciences, geology and other natural sciences. Today the relative measure of what man's mind can encompass and what is available to be encompassed has daily grown further and further apart. Thus one reason for the lack of communication between engineering and medicine becomes evident. When a scientific field has become too departmentalized for its own people to communicate readily with one another, we cannot be surprised at the lack of ready communication and understanding between engineer and physician.

Age is another factor. Because of its long, continuing history (the Hippocratic Oath spelled out the conduct of the profession 2,500 years ago), medicine has acquired a status in our society unique among the professions. It is this time-embedded status that lies behind the occasional attitude of self-sufficiency and aloofness to others who might cooperate in the solution of problems which appear to be essentially medical.

Engineering, on the other hand, although practiced since the time of the Romans, was not formalized until the 19th century. As a newcomer with a spectacular list of achievements, it sometimes betrays a brash sense of superiority that can be as harmful to disciplinary work as the manifestations of medicine's ego.

Another root of divergence is the training and eventual responsibility of practitioners in the two disciplines. The physician by and large functions directly with his patient and is solely responsible for his judgment and decisions.



Calibrated grid case for basic research in arm movements in the Research Division of the NYU College of Engineering.

Engineering is largely a group effort. Although the engineer makes decisions based on his evaluation of a problem, he is taught to function within a team, and most engineering decisions represent group judgment.

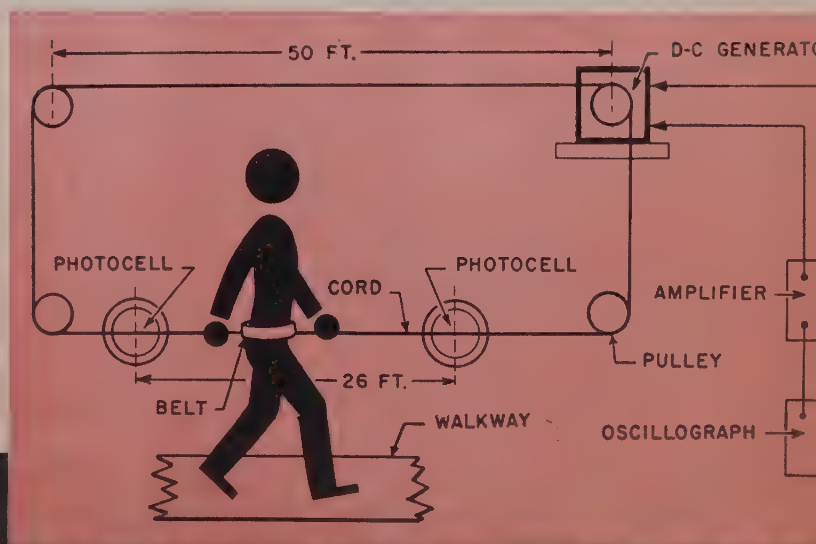
Then and Now

Improved tools and instruments for detection, diagnosis and cure of disease account for a good portion of medical progress. Some of these were developed specifically for medical purposes (sometimes by laymen) but many existed long before they were adopted to medical needs. The microscope existed for centuries before Malpighi applied it to the study of tissue. The thermometer was well known when Sanctorius used it for measuring body temperatures. Benjamin Franklin, versatile but untrained in medicine, invented the flexible catheter. The opthalmoscope was invented by Charles Babbage, a mathematician and mechanical genius, and later was modified by Herman Helmholtz, a physicist and physiologist. Similarly the X-Ray was discovered by Roentgen, and its application to medical needs followed. On the other hand, the string galvanometer, a useful instrument in engineering measurements, was invented by William Einthoven as a laboratory aid in studying the physiology of the heart, and the stethoscope was developed by René Laennec, a physician, specifically for medical purposes.

No evidence exists in any of these instances of a purposeful coordination of effort between the medical and physical sciences. The single area of systematic cooperation between the two disciplines in the 19th and early 20th century was public health and sanitary engineering; the most dramatic instance was the conquest of malaria at the site of the Panama Canal.

Biomechanics is a striking illustration of a bridge between current practice in medical-engineering cooperation and future potentialities. Biomechanics, the science which investigates the effect of internal and external forces on human and animal bodies in movement and at rest, analyzes and resolves the stresses and strains in the muscular and skeletal structure of man. Employing engineering techniques, present studies of the stress distribution of skeletal structures resulting from external forces have afforded the physician data indicating the probable location of a skull fracture when the external point of impact

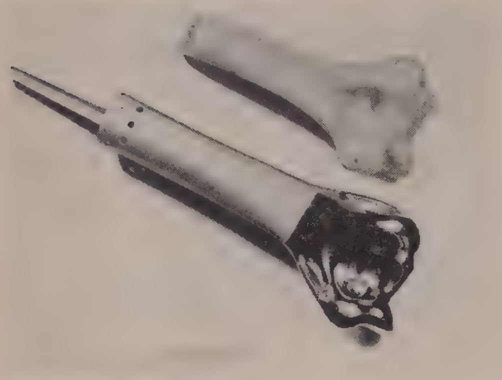
Tacograph system that gives record of velocity in an amputee's walk across an instrumented platform. Pattern of the walk is recorded by interrupted-light photographs of an amputee whose leg is taped with luminous material.



is known. Stress studies are also being conducted on the pelvic girdle, leg bones and other parts of the skeleton. Similarly the electromyograph measures the activity of muscle groups.

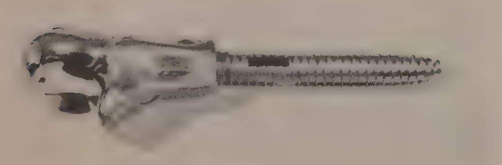
Continuing developments in plastics and metallurgy are finding important applications in orthopedics and prosthetics. Plastics are improving the cosmetic appearance of artificial limbs and face, hand and foot restorations. Combinations of fiber glass and other synthetic fabrics with plastics have been laminated to form the structure of more effective arm and leg prostheses.

New non-corrosive alloys developed a generation ago and first adopted by the dental profession are now being used extensively for comparatively simple orthopedic surgical purposes. Working with the engineers in the laboratories where the alloys were developed, some physicians have used them in unusual situations with apparent success. Bone plates and intramedullary bars or splines of the femoral head and neck are supported with specifically designed appliances. In some cases where the head and neck of the femur have been impaired by disease, satisfactory hip prostheses have been inserted in the upper end of the femur. In at least one instance, a complete elbow joint together with a portion of the ulna and the humerus was successfully installed within the patient's arm.

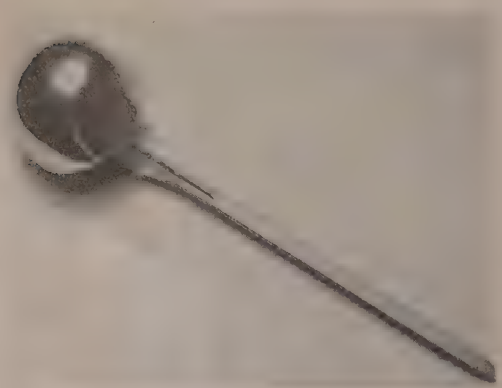


Modified neer shoulder

Mechanical finger joint



Ulna replacement



Elbow replacement

The electron microscope has greatly multiplied the magnifying power of the optical microscope and accelerated the fight against viruses, which can now be seen. Electronic thermometers provide more accurate and continuously self-recording measurement of body temperatures. A recently developed stethograph based on devices that measure surface roughness of machine parts records not only audible but also inaudible heart sounds. Other devices are improving the accuracy of measurement of pulse rate, pulse pressure and blood velocity.

Radar is being used in attempts to map the brain. Sonar is being experimented with to map the body interior. Experiments are in progress in the use of ultrasonics for brain surgery and to destroy interior tissue and formations such as kidney stones.

Radioactive tracers and triangulation techniques are now locating hemorrhages and tumors. Radioactive by-products of atomic fission have increased the potential for controlling cancer in its early stages.

Electronic advances have brought within the range of possibility canes to guide the blind and scanning devices to read to them and have been used to improve hearing aids.

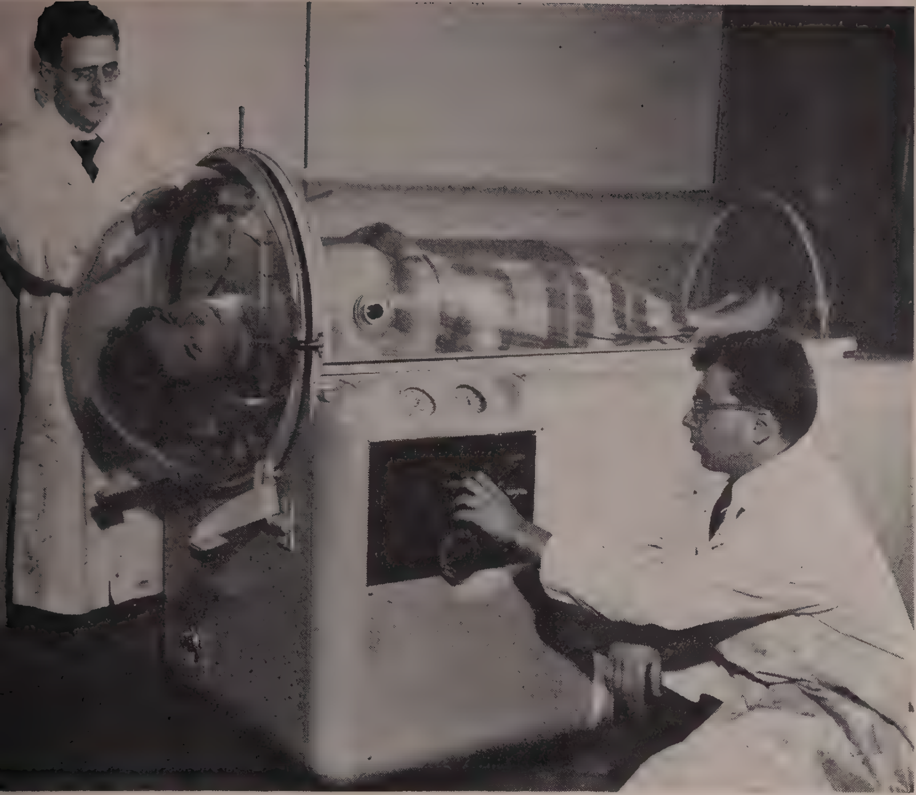
Blueprint for the Future

The most fruitful area for cooperative research will lie in the application to medical use of the new and impressive techniques which have been the major creative efforts of the physical scientists. Here are but a few of the host of research and development tasks which will challenge the cooperative skills of physician and engineer, instrument maker and manufacturer.

- Greater knowledge of the distribution of stress and the deformation which may be tolerated in the major skeletal components during the performance of normal and unusual activities.
- Increased knowledge of muscular activity and the redistribution and compensation which occurs in paralysis.
- More quantitative information of how pathological locomotion deviates from the normal.

Polio victim demonstrates how all-aluminum ladder designed for her by NYU research engineers enables her to climb without the use of crutches. The ladder is collapsible and can be rolled away on wheels.

- More extensive research in the structure of muscular and bone tissues with the possibility of synthetic substitutions.
- Development of improved prosthetic devices and braces better suited to the patient's needs.
- Development of new alloys and synthetic materials having higher strength-to-weight ratios, better corrosion-resistant properties and amenity to simple fabrication for use in orthopedics.
- Development of miniature electronic devices to magnify the electrical potential generated during muscle action; utilization to operate prosthetic devices and restore lost function to amputees or partially paralyzed persons.
- Extension of radioactive tracer and triangulation techniques to locate deep seated infections.
- Study of optical and telemetering techniques to apply them to the scanning of the intestinal tract for evidence of



ransparent walls of this improved respirator give patient increased sense of reedom during treatment. The breathing function and even coughing are perormed for paralysis victims by the respirator.

Curb-climbing wheelchair enables polio patient to mount curb under her own power by rotating handles on arm of chair.

disease.

- Consideration of radar, sonar and other techniques in the development of devices to instantaneously and continuously measure heart volume and arterial blood flow during stress, without at the same time limiting the individual in the performance of stress-inducing activity.

Patterns for Cooperative Effort

Although most medical-engineering research has been conducted by small isolated groups in which the mutual interest of the physical and medical scientist was the binding force, there are instances of organized cooperative medical-engineering research.

Within the Government agencies, the importance of the individual soldier, the complexity of his equipment and the rigors of the various environments to which he is exposed, have made multi-disciplinary research a necessity. The Aeromedical Laboratory, Wright-Patterson Air Force Base, Ohio; the Climatic Research Laboratory, Natick, Mass.; and the Naval Air Material Center, Philadelphia, are some of the agencies employing teams of physicians, psychologists, physiologists, biophysicists and engineers.

Following World War II an institute for research in orthopedics and prosthetics was reorganized at the University of Bologna, Italy to include members of the engineering faculty with the medical faculty in cooperative experimental studies.

Perhaps the largest non-military effort in organized cooperative medical-engineering research is the program financed by the Veteran's Administration and administered through the National Research Council Advisory Committee on Artificial Limbs. Physicians, surgeons, therapists, prosthetists, psychologists, physicists and engineers have participated in this program since its inception in 1945. The bulk of research and evaluation is conducted by the University of California and the Research Division of the New York University College of Engineering with other agencies participating. The physical scientists and engineers have created new tools for the study of locomotion and other physical activities. With guidance from the physician in what the body can and cannot tolerate, new prosthetic devices have been developed, existing techniques have been analyzed and improved and new materials adapted to these devices created, all to the benefit of the amputee population and society in general.

A Committee of Engineers Cooperating in Medical Research was established in 1948 under the auspices of the Engineers Joint Council. This committee met occasionally to consider new equipment needed for cancer research. Their recommendation to establish an Institute for Medical Engineering, however, was never realized.

Where to Start

There are three conditions necessary for cooperative research in medicine and engineering: (1) the medical profession must create the proper environment for cooperative medical-engineering research. It must accord greater and equal recognition to the contributions of the engineer and physicist. (2) The engineering schools must provide proper training for the engineer who is to cooperate in medical research. Biomechanics, "human engineering", physiology and anatomy should be included in the curriculum. The individual should be related to his environment in terms which the engineer can understand. (3) Industry should supplement funds from government and foundations for medical-engineering research. This project should be supported by large equipment and instrument manufacturers, whose present area of activity may be readily related to needed medical equipment as well as by those organizations already engaged in the design and fabrication of medical equipment. This is not entirely an altruistic move. Certainly evidence exists that equipment developed for a specific purpose has brought profit from other unexpected and more extensive non-medical applications.

When the medical practitioner is convinced that medical-engineering research can produce many new tools with which to combat disease—when the engineer is assured that a medical-engineeering career can be stimulating and secure—when the industrialist is confident that medical-engineering developments can bring his organization recognition and profit—then we may expect a burgeoning of medical-engineering efforts—and then the new discoveries of the era will be used not only in the advancement of man's comfort but also in the improvement of his well being. ⌘

Research Costs

Robert A. Hussey, *Business Manager*
Herbert T. Tiffany, *Head Accountant*

Ordnance Research Laboratory

COST ACCOUNTING for research poses many problems. Some are financial; others concern the attitudes of research scientists and directors of research. In many cases, perhaps the majority, these problems require some compromise from good accounting practice.

Many research laboratories are so organized that proper accounting procedures are possible. In many instances the revenues are adequate to justify the more detailed and precise accounting; in others the sponsors require sound accounting of their funds. It is probably fair to say that in these cases the research scientists have reconciled their fate to a system providing financially agreeable work.

There are also research laboratories which can neither afford nor justify (to the researcher) the time or expenditure necessary to maintain an adequate system of cost control. A cost system becomes obnoxious to the scientist because of the demands and restrictions he feels it places upon him. He feels his research activities must be unhampered by the very thoughts of reporting his research time upon various projects or filling out a requisition for stores. The petty inconveniences disturb the train of thought necessary to successful researching.

This article describes a compromise system of costing research in a smaller, yet almost self-sufficient, research Laboratory working on naval ordnance on a University campus. This Laboratory was organized during the waning months of World War II, at a time when the development of new weapons was extremely urgent and Government funds for such purposes were plentiful. The need for research accounting or budgetary control was not even considered. With the reduced availability of Government research funds in recent years coupled with the necessity of sponsoring agencies expending available funds in a more orderly fashion, costing for budget purposes became more necessary.

Some time was needed to develop the system which seemed to meet the needs of the sponsoring agency and Laboratory Administration from the standpoint of preparing the annual budget and costing the projects against the budget and at the same time overcoming the more serious objections of the scientific staff. It was also necessary that any system of costing should tie in with the University accounting system. For the reader to gain the proper perspective of the overall situation, here's a brief outline of the Laboratory organization.

The Laboratory is organized on a "projects" basis as an outgrowth of a combination system of projects and subject matter. The task assignment made by the sponsoring agency requires expenditure against a score or more of research projects or project problems. These projects are divided into research projects and engineering projects each headed by an assistant director. Another facility designed and built by the sponsoring agency for special research and development projects is headed by a third assistant director.

The service divisions of the Laboratory are organized under three other heads operating on the same staff level as the assistant directors. The Engineering Services Division is organized on a subject basis to provide the Laboratory with a group of highly trained experts in each of the areas of specialization necessary for carrying out the work of the Laboratory. This division, the largest, is composed of Electronic, Acoustic and Mechanical Construction each of which is responsible for most of the research development and construction done within the Laboratory. Service functions are performed by Drafting, Data Analysis, Photography and Editorial Staff. The Laboratory maintains four field stations operated by engineers and technicians. The personnel at these stations are supervised and considered a section of Engineering Services.

Personnel and Accountant

The work force of the research Laboratory contains researchers who may be nationally or even internationally outstanding in a particular field of scientific endeavor. Some hold undergraduate degrees and many have master and doctor degrees. An accountant cannot employ the same philosophy in dealing with this type of business associate as he could if the business were manufacturing, mining, transportation or retail selling. The accountant who attempts to force upon research management at any level the same approach as may properly be applied to a manufacturing operation is making as serious a mistake as the research director who takes the position that cost accounting has no place in a research laboratory. But the accountant must do his job. If he neglects to compile accounting information necessary for management purposes, to present properly financial and operating statements, or to support billing to contracting agencies of the Government or other clients for whom work may be done, he is open to equally valid criticism.

Research is gravely in need of assistance which the well

qualified accountant can offer. Therefore, it is imperative that the accountant add to his wealth of financial and business management knowledge and understanding of the peculiarities of this unique field of organized endeavor. In this manner the accountant can take the place which is rightfully his in the research organization, a place which must be capably filled if the modern research laboratory is to be managed intelligently.

Accounting techniques must measure up to the requirements of operating conditions and must assist in reaching the goals for which the enterprise was formulated. It is in the consideration to be given various elements of cost encountered in daily performance of research tasks that the accountant must adopt both a philosophy and an accounting technique which may appear to be drastically different from the ordinary. Nevertheless, differences required by a specialized application of accounting cannot be considered to be deviations from sound and fundamental "common-sense" accounting theory.

The Budget

The work at this laboratory is financed by an appropriation from the Defense Department. This agency distributes these funds to the different projects to be handled at the laboratory. In this way, the Administration has a tentative starting budget.

At the beginning of a fiscal year the Administration establishes a budget for each project to be in operation during the year. This budget serves as a yardstick against which to measure actual performance as it unfolds. It can and should serve the dual function of a standard for control purposes and a forecast for shaping forward plans. The budget must be relatively fixed to have any value but it is reviewed periodically by the Administration and may be modified to reflect new facts, changed circumstances and altered plans.

Accounting Procedure

The procedure for arriving at costs can be broken down into six major steps.

- Reporting time
- Calculating direct labor costs
- Distribution of overhead
- Direct charges for materials, services and travel
- Apportioned charges
- Budget and Cost Summary

Reporting Time: We have used different methods for reporting time. One method was reporting by departments. This required the department to accumulate time and report it in total to the cost accountant. In another method each person reported his time directly to the cost accountant. This burdened the cost accountant with an enormous amount of detail work. To reduce this detail we now have the scientists, engineers and other direct project personnel reported monthly by the project leaders in units of tenth's to the cost accountant.

The project leader at the end of the month reviews the work done by scientists and engineers under his supervision and reports a one point (1.) if he works full time on one budget. If his time is divided between other budgets, it is reported in tenth's to each budget as in Figures 1A and 1B. This system is less complicated for the project men and much faster and more accurate in calculating cost charges.

The Engineering Services Department which is composed of Shops, Electronics, Acoustics, Drafting, Data Analysis, Editorial and Field Stations reports on an hourly basis according to the budget of the Manager of Engineering Services. The personnel in these departments are working on all budgets; therefore, to arrive at an actual cost we must work on an hourly basis. Each person's time is accumulated by budget categories for the month and reported to the cost accountant.

Calculating Direct Labor Costs: Perhaps our system of calculating direct labor costs for scientific and engineering personnel may be questioned by many cost accountants. We consider that each engineer is working full time on either one or more budget categories. Therefore, his total salary for the month is used for cost distribution. Many

Fig. 1A MONTHLY TIME SHEET
Project Time To Be Reported in Tenths

Project Leader John Doe Month of Project No. A

	BUDGETED PROJECT NUMBERS			
NAME	A	B	C	D
John Doe	1.			
Monthly Salary	750.00			
William Black	.2		.3	.5
Monthly Salary	105.00		157.50	262.50
John Jones	.1	.9		
Monthly Salary	52.50	472.50		
Total Scientific Time	1.3	.9	.3	.5
Total Scientific Salaries	907.50	472.50	157.50	262.50
Non-Scientific Time				
Mr. X	1.			
Monthly Salary	400.00			
Mr. Y	.1	.8		.1
Monthly Salary	40.00	320.00		40.00
Secretary	.5	.1	.2	.2
Monthly Salary	100.00	20.00	40.00	40.00
Total Non-Scientific Time	1.6	.9	.2	.3
Total Non-Scientific Salaries	540.00	340.00	40.00	80.00

Salary distribution made by the Cost Accountant.

Fig. 1B ENGINEERING SERVICES
Daily Time Sheet

Please turn these over to your secretary on Saturday of each week
Do not include budget numbers not listed for this purpose.

NAME: John Doe (41.5) WEEK ENDING:

Budget	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Total
A	2	7.5	3.5		1		14
B			4	7.5			11.5
C	5.5				6.5	4	16
Total	7.5	7.5	7.5	7.5	7.5	4	41.5

Remarks:

cost accountants and especially project leaders believe that vacation, sick leave and holidays should be treated as indirect costs.

The costing is made very simple by distributing the engineer's salary for the month by tenth's to the budget categories as reported by the project leader. As shown in Figures 1A and 1B, a summary of man months and cost for each project under his supervision is definitely established.

Engineering Services Report is costed by multiplying each man's rate by the number of hours actually worked on a budget category. The costs as arrived at in detail are accumulated on the Final Cost Summary.

The Engineering Services details are important records for the cost accountant. Frequently administration or project leaders ask the cost of a certain piece of work and whether the department is producing the work according to estimates or to a specific budget they must meet.

This system of arriving at direct labor costs may seem to be time consuming in details, but once the system has been used, it is surprising how quickly it is completed. At present, this organization records the time of 150 men, and a complete summary of labor costs is completed by the 10th to 15th of the month.

Overhead in this organization is the amount paid to the University for its participation in the Defense Department Contract. The rate paid to the University is negotiated yearly. This reimbursement to the University covers light, heat, power, building use and other expenses involved in handling the contract. Overhead as considered here would not arise in most types of cost accounting.

In this instance it is considered an additional cost per hour of scientific and non-scientific salaries. Therefore, to calculate the overhead for each budget category, we multiply total salary charge by established overhead rate.

Other Direct Charges: Direct materials and services, travel, retirement and telephone toll calls during the month can be charged directly to the budget category.

Direct materials and services are important items of expense to the Administration and project leaders. We require that each purchase order be definitely marked if the material or service is to be purchased for a specific budget. Each day the vouchers paid are summarized to each budget by the cost accountant.

Because our type of organization requires liaison work with other Navy organizations, the travel account is an important cost factor. Each trip is authorized by an assistant director who reports the budget to be charged. These charges are summarized daily by the cost accountant.

Telephone toll charges are a minor cost if evenly distributed to each budget. In our type of work some budgets require a large number of calls where other budgets are more or less pencil projects and work is accomplished at the home Laboratory. Therefore, the cost accountant distributes the toll calls to the budget.

A retirement contract for Laboratory employees has been negotiated with an outside insurance company. The Laboratory is obligated to pay a matching premium to that paid by the employees. This charge is distributed to the cost by multiplying the budget salaries by the set rate.

Apportioned Charges: We have up to this point established all direct charges to the budget as labor, University overhead, direct materials, services, travel and other miscellaneous charges. The difference between the total monthly costs and direct charges are considered apportioned charges. Our organization is such that total costs must be distributed to some specific budget. Therefore, administration, other contract performance costs, building maintenance and security must be distributed.

A method for distributing apportioned charges is a debatable issue. The question arises whether it should be based on scientific time, total direct labor charges or total direct costs. Each system has its merits, and the cost accountant will find this procedure hardest to settle.

Research and production projects in this Laboratory range from a very few problems which require only a chair and table at which the scientist may work with a pencil and paper to tasks calling for huge investments in specialized equipment, apparatus, facilities and supporting services. The Administrative Staff Committee has ruled that in order to distribute these apportioned charges more equitably the rate should be based on the total direct labor cost (with proportionate share of University overhead) of the budget.

To accumulate all the costs for each budget the cost accountant will prepare a schedule (Fig. 2) showing the breakdown of costs as previously described. This schedule gives the project leader a chance to further review his various charges in condensed form.

Fig. 2 **BREAKDOWN OF MONTHLY COSTS**

Budget	Scientific Salaries	Non-Scientific Salaries	Total Salaries	University Overhead	Direct Materials	Other Direct Charges	Total Direct Charges	Apportioned Charges	Total
A	$ 2,173 00	$ 1,005.42	$ 3,178.42	$ 635.68	$ 8.50	$ 249.81	$ 4,072.41	$ 4,116.68	$ 8,189.09
B	1,512.00	194.40	1,706.40	341.28		464.44	2,512.12	2,212.72	4,724.84
C	989.80	1,312.11	2,301.91	460.38	690.72	153.90	3,606.91	2,981.16	6,588.07
D-1		217.53	217.53	43.51		10.88	271.92	281.31	553.23
D-2	550.00	138.44	688.44	137.69	52.49	34.42	913.04	891.95	1,804.99
D-3	619.40	387.34	1,006.74	201.35		50.34	1,258.43	1,307.05	2,565.48
E		141.68	141.68	28.34	247.87	7.33	425.22	185.25	610.47
F	4,002.80	2,779.19	6,781.99	1,356.40	4,058.67	705.01	12,902.07	8,785.68	21,687.75
G	1,547.80	937.14	2,484.94	496.99		967.14	3,949.07	3,217.87	7,166.94
H-1	1,569.20	84.00	1,653.20	330.64		82.66	2,066.50	2,140.67	4,207.17
H-2	438.00	192.61	630.61	126.12		31.53	788.26	816.47	1,604.73
H-3	2,739.00	2,947.18	5,686.18	1,137.24	838.10	1,464.25	9,125.77	7,368.85	16,494.62
Total	$16,141.00	$10,337.04	$26,478.04	$5,295.62	$5,896.35	$4,221.71	$41,891.72	$34,305.66	$76,197.38

Budget and Cost Summary: The final step is to accumulate all costs in a statement for distribution to Administration and Departments. This statement will show the budget and costs for each project on the actual monthly figures, the actual fiscal year to date figure, and the balance in the annual budget. (Fig. 3).

This statement at a glance shows the Administration how budget and actual performance compare. This type of information assumes major importance to a project leader who must adjust his personnel and purchasing problems to his needs and still stay within his budget. The Administration can more easily evaluate the work of the project, as it progresses from month to month, and, as the budget period draws to a close, plan for the next year.

The Benefits

We have found after five years of issuing cost statements to the Administration that in many ways they have helped with the planning and negotiations for new projects.

The Administration has before them a monthly distribution of costs for each project which they can compare with the amount of work accomplished as reported by project leaders and departments. The budget and cost summary statements will reflect the cost in proportion to the budget. The Planning Coordinator must have these cost figures in order to adjust his project planning with the project engineers. These cost reports over a period of time will give the Planning Coordinator a basis to estimate time and costs on planning for future projects. These estimates will be forwarded to the Administration to give them comprehensive figures to request new appropriations.

Project leaders are informed not only on their direct project costs and budget, but also on the cost of work expended by the departments of the Laboratory on their project. With these cost figures before them they can better control the cost on their project for departmental work done, since they can estimate future costs.

Finally, in working on a set appropriation, all Administrative Officers must be aware at all times of costs. Cost controls involve action on the part of people responsible for expenditures; therefore, control is a human, and not a paper problem. Refinements in the costing procedures are the daily aim of the Accountant and one of the best sources of greater accuracy and acceptance in the solution of more direct costs. ✖

Fig. 3 BUDGET AND COST ACCOUNTS FOR PERIOD ENDING

Budget	Monthly Budget	Monthly Actual	Fiscal Year Budget	Fiscal Year Actual	Unexpended Budget
A	$10,416.00	$ 8,189.09	$ 31,248.00	$ 21,530.83	$103,469.17
B	6,666.00	4,724.84	18,998.00	12,927.86	67,072.14
C	5,000.00	6,588.07	15,000.00	18,618.11	41,381.89
D-1	833.00	553.23	2,499.00	542.40	9,457.60
D-2	2,083.00	1,804.99	6,249.00	5,827.59	19,172.41
D-3	1,666.00	2,565.48	4,998.00	6,969.69	13,030.31
E	4,166.00	610.47	12,498.00	3,519.71	46,480.29
F	18,333.00	21,687.75	54,999.00	55,296.07	164,703.93
G	11,666.00	7,166.94	34,998.00	31,203.62	108,796.38
H-1	6,666.00	4,207.17	19,998.00	9,889.31	70,110.69
H-2	4,166.00	1,604.73	12,498.00	7,787.79	42,212.21
H-3	13,750.00	16,494.62	41,250.00	53,988.01	111,011.99
Total	$85,411.00	$76,197.38	$255,233.00	$228,100.99	$796,899.01

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RESEARCH & ENGINEERING
The Magazine of Research and Development Management

REACH THE MEN WHO "RUN THE SHOW"!

Shields Against the Spears: Sylvania Intensifies "Active Defense" Program

WALTHAM, MASS.—The problem of detecting and destroying any missile, present or in prospect, that might threaten the nation is under intensive study by the Missile Systems Laboratory of Sylvania Electric Products Incorporated at the Company's completely new Waltham Laboratories, a facility of its Electronics Systems. The large number of scientists and engineers committed to this study reflects the confidence of Sylvania and of the Government that the study of "active defense" against guided missiles is now feasible, that evacuation of areas under missile attack is not necessarily the only means of defense. Since little precedence for this work exists, the Laboratory is not only studying existing missile theories, but is also evolving new theories and new designs with the purpose of developing an optimum defensive system. The problem involves thinking through in advance the strategy, tactics and logistics of missiles still in process of development. Each step toward a solution is a series of complex problems which draw on the combined knowledge of mathematicians, physicists, aerodynamicists and engineers.

The Waltham Laboratories building, dedicated September 15, also houses the Avionics Laboratory, formerly Sylvania's Boston Engineering Laboratory. Designed to grow with the expanding future of the science of electronics in industrial as well as military applications, the new building has been increased to 120,000 square feet from its originally planned size of 80,000.

Avionics—the application of electronics to aviation—is a relatively new field in the science of electronics. The Avionics Laboratory is engaged in research and development of a wide range of avionic equipment, including air and surface search radar, airborne radar, electronic counter-measures, communication, and navigation and guidance equipment.

Systems Approach Emphasized

Sylvania brings to the new laboratories its successful experience with the "systems approach" to research and development of aviation equipment. This approach is characterized by its emphasis on optimization of systems rather than of components. Problems are thought through in advance with the purpose of obtaining the best possible solution. Systems engineers are not limited in their thinking to use of components available within Sylvania. Their primary concern is with the success of their work. They are free to consider initiation of new component developments or even the use of competitors' products if necessary.

The obligation of the systems groups to produce the best possible system is consistent with Sylvania's decentralization philosophy. The company feels that independent responsibility of the Electronic Systems Division keeps the other company divisions on their toes fulfilling component requirements. Result: better equipment is produced throughout the company.

The general organization of the Avionics Laboratory conforms to and supports the "systems approach". An applied research group does the required background study and is responsible for originating the general system configurations. Systems design groups fill in the system configurations to complete the system designs, including the input-output relations for each component. Components groups procure the required components, if possible from within Sylvania or from a subcontractor. A system development group designs and develops the physical equipment for wiring, packaging and protecting the systems in accordance with the specifications set by the applied research and systems groups.

An important advantage of the "systems approach" is that by fully specifying component requirements in advance, expense and time are not wasted in obtaining or developing components that are better than the system requires.

Freedom from Administrivia

A guiding principle in the administration of the Waltham Laboratories is that technical people should be as free as possible to do the technical work for which they have been trained. Administrative detail, called "administrivia" by R. W. Couch, business manager, is separated from technical administration and assigned to the business service groups. If an engineer finds himself involved in administrivia, he is expected to call on an administrative assistant for help. In fact, if he won't let go of such detail, he is persuaded to join a business group.

Technical administration, of course, must be left in the hands of technically trained people. A scientist or engineer at the Waltham Laboratories has the opportunity to work towards a management position or to remain in purely technical work. The opportunities for recognition and reward in either direction are equal and depend only on individual abilities.

Guided missiles and the development of electronics means to detect and destroy them are a primary concern of the new Sylvania Waltham Laboratories. Discussing the problems presented by an enemy missile and equations of its path are (left to right) Dr. O. G. Haywood, Manager of the Waltham Laboratories; Paul Black, Manager of the Avionics Laboratory; and Dr. E. G. Schneider, manager of the Missile Systems Laboratory.

Antibiotics Will Lead To Better-Fed World

AUGUSTA, GA.—A new use for antibiotics—food preservation—was described by an eminent food technologist who predicted this development will give the world better, safer and more varied foods at lower cost. Spoilage of meat, milk, leafy vegetables, poultry and fish can be averted through use of the same antibiotics that have controlled scores of diseases that afflict man.

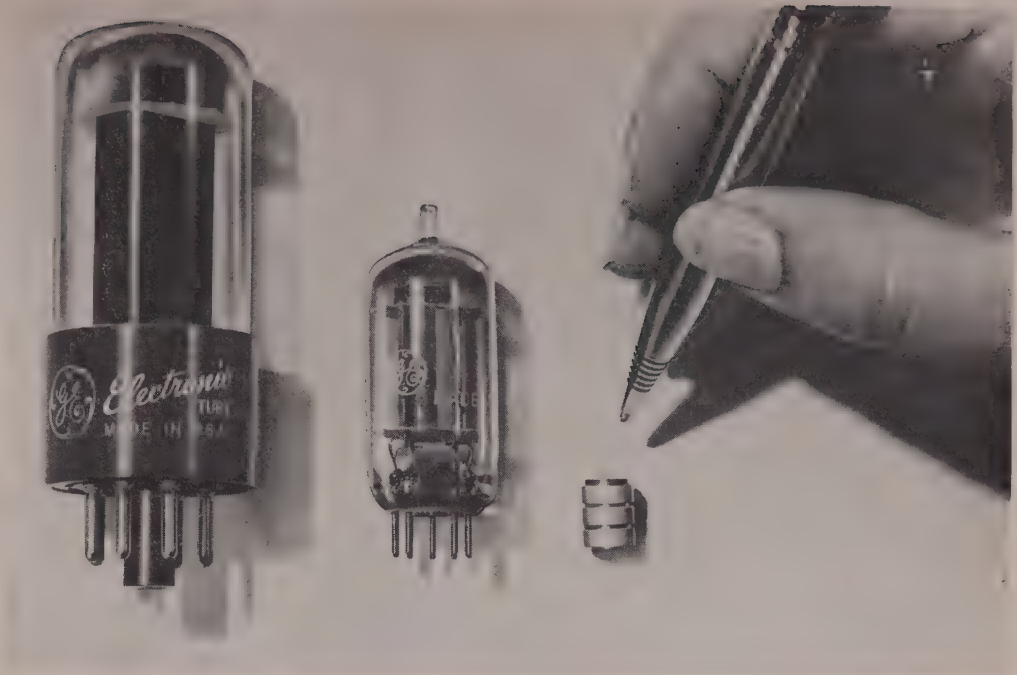
Speaking at the International Association of Milk & Food Sanitarians, Dr. C. L. Wrenshall, of Chas. Pfizer & Co., Inc., said that antibiotics could be used with or without refrigeration, with the added advantage that they will not cover up damaged, contaminated or inferior foods.

"In addition," he said, "antibiotic residues may present little or no problem, since antibiotics, relatively unstable compounds, lose activity during storage and and are easily destroyed by heat, as in cooking."

In his report, co-authorized with J. R. McMahan, also of Pfizer, Dr. Wrenshall outlined the economically feasible applications of antibiotics.

- A few parts per million of a broad spectrum antibiotic can inhibit the bacterial spoilage of fish.
- Only 10 parts per million of a broad spectrum antibiotic added to the slush ice in processing increases the time poultry can be held without spoilage by 50 to 100 per cent.
- It is possible to delay bacterial spoilage of various cuts of meat and even contaminated meat by dipping or infusion with antibiotic solutions. Whole carcasses can also be successfully treated, preventing spoilage and leading to the possibility of aging beef at higher temperatures, or of extending the safe handling period in the absence of refrigeration.
- One part per million of a broad spectrum antibiotic added to raw milk at the time of milking will delay the onset of souring for 24 hours without refrigeration. If the milk is first pasteurized, antibiotics will avert spoilage for periods ranging from two days to several weeks depending on the storage conditions and the concentrations of antibiotics used.
- Dipping a salad mix for five minutes in a solution of terramycin or streptomycin will double the shelf life of prepackaged salad mixes which are easily affected by bacterial soft-rot.

Dr. Wrenshall said that while the Food and Drug Administration has not yet approved the direct addition of antibiotics to foods, these drugs are being used in important areas closely related to food applications: animal and poultry feeds and in the control of certain plant diseases.



Milestones in radio and television receiving tube development. At left, conventional glass type with plastic base; center, miniature type tube; right, new ceramic "micro-miniature" developed by G-E.

GE's New Vacuum Tubes: The Revivification of a Dying Duck

SCHENECTADY, N. Y.—"Since the revolutionary development of the transistor, there has been a tendency in some quarters to assume that the vacuum tube is a dead duck. Even more thoughtful persons have expressed concern that research and development on vacuum tubes might become neglected in favor of semiconductor research. But the remarkable achievement of miniature ceramic vacuum tubes with their exceptional capabilities at microwave frequencies and their phenomenal high-temperature tolerance—which the transistor cannot even approach—shows that the vacuum tube art is far from dead." With these words from Dr. C. G. Suits, Director of Research, GE released the technical details and the research story of a series of tubes that should end all talk of the industry's imminent demise.

Details of New Tube

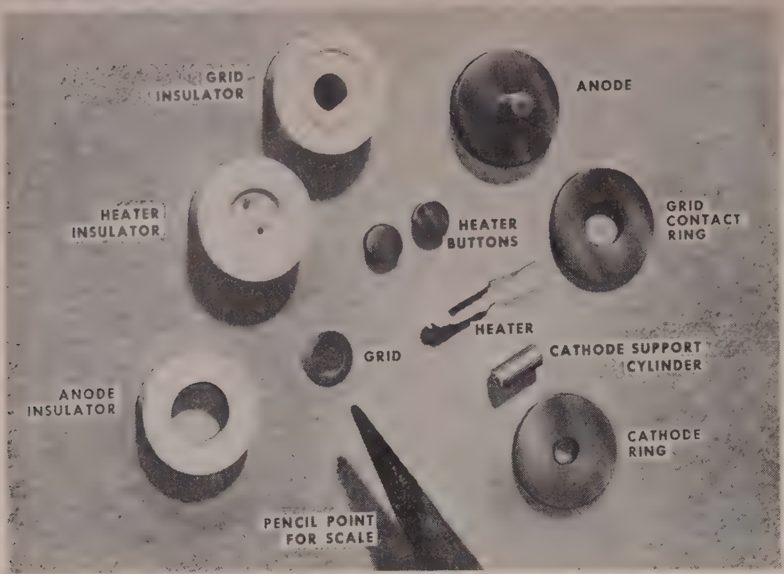
GE's micro-miniature electron tubes are as small as transistors, mechanically rugged to a new degree and operable at guided missile temperatures. First commercially available tube will be the 6BY4 rated for use as a radio frequency amplifier for frequencies up to 1000 mc/sec. Because of its low lead inductance, interelectrode capacitance, low noise, high transconductance, reduced transit time and high operating temperature of up to 500° C, the tube will speed improvements in UHF-TV and military equipment.

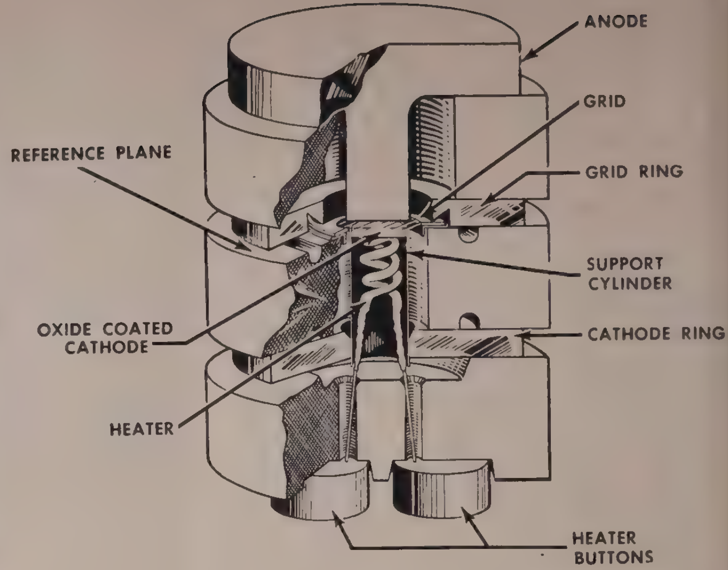
Made of alternate ceramic and metal layers the new tube is ⅜ in. long and 5/16 in. in diameter. The temperature coefficient of the titanium used for almost all the metal parts is matched by the newly developed ceramic body material. Ceramic reference planes maintain tight tolerances on the interelectrode spacings as shown in the accompanying illustrations.

Rigidity of the novel construction results in less relative internal movement of parts when the tube is subjected to mechanical shock, thereby reducing microphonic output. Moreover, the grid wires are wound in tension so that the grid has no self resonance below 20,000 cycles per second. Conventional tubes yield microphonics as high as 100 times above the minimum measurable value; the 6BY4 failed to produce any measurable microphonic output when used on a standard noise and microphonics test set.

The ceramic-metal construction of these tubes promises successful operation at temperatures far in excess of that obtainable with conventional glass tubes—a direct result of the materials and processes used in construction. Conventional soft glass tubes are not rated at bulb temperatures above 225°C, although some hard glass tubes have been made with ratings of 300°C. Ceramic tubes of this construction have been operated at temperatures above 500°C for longer than 500 hours.

Electrically, the planer electrode arrangement has helped to fill the need for high gain, low noise figure tubes for receiving applications to 1000 mc/sec. (Although many features of the 6BY4 design contribute to this improved performance, the low lead inductance and nearly complete





Two heater connection buttons are sealed to a bottom ceramic spacer. The titanium cathode ring lies on top of the heater insulator spacer and is shaped like a washer with the cathode support attached by welds to the inside of the hole. The cathode cover disk carrying the active material is welded to the cathode support at the top and heated by the self-supporting heater coil which extends through the cathode assembly. Completing the heater cathode assembly, the ceramic cathode insulator lies on top of the cathode washer.

Grid assembly consists of an inner grid support washer on which the grid is wound and an outer grid ring which is recessed to hold the inner washer. Grid is made with 0.0003″ diameter wolfram wire wound at about 1000 turns per inch. These wires are brazed to the wolfram support washer to provide a rugged mechanical assembly. Titanium outer washer with the inner washer in its recess fits on top of the grid cathode ceramic spacer, providing a nominal hot grid—cathode spacing of 0.0006″. The grid insulator ceramic rests on the outer grid washer. A flat disk with a round post rising from the center of one side, the titanium anode rests on top of the grid insulator with the anode post projecting downward over the grid to form the working plate area. Nominal grid-plate spacing is 0.007″. In the finished type, seals which remain vacuum tight above 700°C are made between each titanium ring of the adjacent ceramic spacers.

isolation of input and output circuits are major factors.) In conventional miniature tubes, the functional electrodes, plate, grid and cathode are connected to the circuit through the base pins and inner stem leads of the tube having a small surface and relatively large length. The connectors form an appreciable inductance between the circuit and the functional electrodes. In a UHF amplifier circuit, some of the amplified signal is lost in this inductance and does not contribute to the amplifier performance.

Micro-miniature ceramic construction allows the circuit to be connected to the electrodes through metallic disks, which form a short connection with relatively large surface area. Inductance between the electrodes and the circuit is, therefore, very low and little of the amplified signal is lost, thus increasing the performance over an equivalent tube of conventional construction. In addition the construction interposes the grid and its connector as a shield between the plate and the cathode, providing nearly complete isolation between the input cathode circuit and the output plate circuit. Coupling between input and output circuits is reduced with a consequent improvement in performance.

Research Story: New Knowledge, New Materials, New Processes

The research story of this development is an example of how the three "products" of research—new knowledge, new materials and new processes—can be incorporated into a single package. The new knowledge includes original and radical concepts of tube design, new understanding of the cause of "noise" in electron tubes, basic research in very high emission, low temperature cathodes and the uncovering of some fundamental facts about titanium. New materials are the ceramics specifically developed to match the thermal expansion properties of titanium. New processes were required for the new kind of grid and for metal-ceramic seals that could hold a vacuum under adverse operating conditions. In the search for ways to simplify construction, researchers were constantly faced with the problem of gettering—sopping up the gas released during operation—inside a very small envelope.

As frequently happens, research in another field provided the answer. GE researchers found that titanium has almost unbelievable gettering properties coupled to other properties important to the development of miniature vacuum devices: low vapor pressure, high melting point and excellent sealing characteristics. Researchers also determined that titanium can be "degassed" at 800°C, well below the temperature required for any other metal tested. Since uniform emission requires freedom from poisoning contaminants, titanium is particularly valuable because it can be degassed at a temperature below that at which an oxide cathode activates.

Mass spectrometer measurements showed that degassed titanium will getter a wide variety of gasses, some even at room temperature. Equally important is the fact that titanium continues as an active getter throughout the life of the tube. Of all the gasses gettered, only hydrogen is evolved on reheating to a high temperature. Thus by using both hot and cold titanium, remarkable gettering was achieved. These properties were used both by employing titanium as the principal structural material in the tubes themselves and also by placing it on the walls of the high-temperature vacuum ovens in which the tubes are made. Titanium seemed the key to the development of a tiny, rugged, low-noise tube. But there remained the task of finding insulating disks to be used between slices of titanium in the projected sandwich-like mechanical design. This problem was solved with the development of a series of ceramic materials.

Electronic requirements of tubes for use at high frequencies dictate the geometry of the elements—flat planes. Therefore, grid structures are a series of equally spaced wires soldered to a flat frame. During operation the wires become heated by direct radiation from the cathode and by electrical energy dissipated in the grid itself, causing changes. To circumvent possible distortion, researchers developed unique methods for winding the tiny grid wires, for mounting them under tension and for non-destructive testing of completed grids. The use of titanium-matching ceramics made it possible to discard the use of soft solders in the construction of small tubes. The method of sealing metals and ceramics at temperatures in the vicinity of 1000°C added to the ruggedness and consistent operating qualities.

This development is ample evidence that the well-publicized transistor will not monopolize future electronic progress.

Neutron Counts May Speed Soil Research

WASHINGTON, D. C.—Experiments with electronic atomic-particle counters for measuring soil moisture may aid farmers in planning and using irrigation techniques. Dr. C. H. M. van Bavel, in charge of this research, hopes to obtain in a few years, from the fundamentally statistical studies now under way, information that will greatly reduce the number of years expensive field experiments must be run. Headquartered at Raleigh, N. C., Dr. van Bavel is employed jointly by USDA's Agricultural Research Service and the North Carolina Agricultural Experiment Station.

Information from the studies will help a farmer using irrigation to determine the best time to apply water. He must know the water-holding capacity of his soil, the daily rate of evaporation of soil moisture after a soil-filling rain, and the level of available soil moisture he wishes to maintain. Barring additional rain, he can then predict the day soil moisture will be depleted in a particular field.

Dr. van Bavel and his co-workers are investigating the use of an electronic device, the neutron counter, for providing an accurate, practical measurement of soil-moisture content and depletion. This counter contains a fast neutron source—beryllium mixed with radium. Underground, the fast neutrons penetrate everything but hydrogen—a component of water. When they bounce off hydrogen nuclei, the fast neutrons become slow neutrons, which can be counted electrically and translated into a direct reading of soil moisture.

A new, experimental two-piece portable counter is under development, which is expected to furnish soil-moisture measurements at specific depths, plus information about soil density. One piece of this equipment emits gamma rays and neutrons; the other, located at the same soil depth but at a different site, measures the penetration of these atomic rays or particles.

Nitroparaffins Now in Commercial Production

NEW YORK, N. Y.—The world's first full scale nitroparaffins production facilities are now in operation at Commercial Solvents Corporation's Sterlington, Louisiana, plant, J. Albert Woods, President, announced.

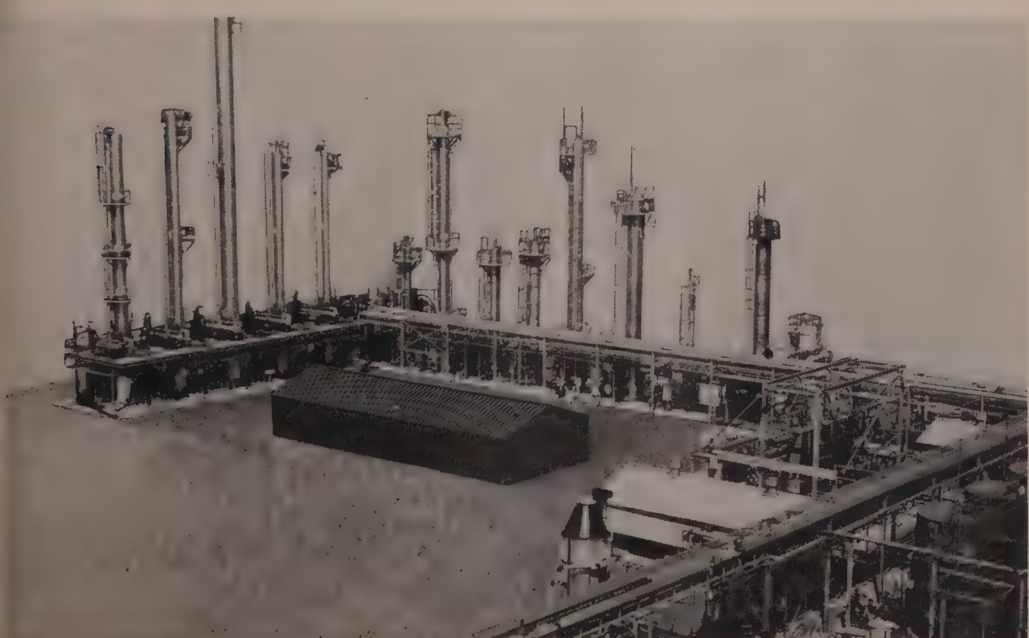
Never before available to industry in volume, this new family of chemicals will initially be used by the textile, surface coatings, petroleum, photographic and chemical specialties industries, he said.

Other industries in which the nitroparaffins will find use are plastics, cosmetics, pharmaceuticals manufacture, aluminum and light metals processing and pesticides manufacturing.

"There is no apparent limit to the application of the nitroparaffins in industry and agriculture," Mr. Woods said. "They constitute an entirely new field of organic chemistry. The importance of the nitroparaffins is their amazing versatility when used as raw materials in the production of other chemicals."

The completion of the new full scale facilities is another step forward in CSC's long-term petrochemicals development program. The Company is currently considering further expansion of present production, as well as developing additional nitroparaffins from 2,000 known possibilities.

The patented processes on which the project is based were developed in Commercial Solvents' Research laboratories from initial research conducted by Purdue Research Foundation. The nitroparaffins have been under study by CSC since 1935.



Nitroparaffin plant, Sterlington, La. Plant arrangement allows maximum flexibility for the building of additional nitroparaffin units. Low structure in foreground is control building.

Five Future Electronic Developments Possible From Present Knowledge

LAKE PLACID, N. J.—Five electronic developments of the future now seem possible on the basis of present knowledge according to Dr. E. W. Engstrom, Executive Vice-President, Research and Engineering of RCA.

- Mural television, in which the receiver will consist of a thin screen that may be hung upon a wall and controlled remotely from a small box carried around by the viewer.
- Portable television receivers, employing the same type of thin screen and operated by batteries.
- Television tape recorders for use by the broadcasting industry in receiving and storing network and other color television programs for rebroadcast.
- Home television tape recording equipment that may be used for recording scenes to be played back on the television receiver, or for recording favorite television programs for repeated playback.
- Electronic music synthesizers, capable of producing any known tone or any tone which may be imagined, for use as a new source of recorded music.

Dr. Engstrom received the Society of Motion Picture and Television Engineers Progress Medal Award "for his outstanding leadership and vision in sound motion picture and television development."

"We are in an era of quickening pace in research and in the application of research results," he said. "Since the war, there has been a rapid growth in the magnitude of scientific research efforts in this country and abroad. This research has been conducted on an ever broadening base. Emphasis on applications has deepened. The time that must elapse between a research result and practical use is progressively being shortened. Certainly never before has the field of research been so fertile from all these points of view."

Dr. Engstrom emphasized the general advance in all scientific research, but he pointed also to "a problem which arises because of the very magnitude of all this progress and because of the power inherent in the new instrumentalities. How shall these advances be used—for gain or for loss? Surely you and I immediately answer—for the good of all mankind. But are people over the whole world so disposed and of one mind?

"As we labor to bring these new instrumentalities and services into being, as we labor to put them to use, let us individually and collectively strive so as to be sure that their uses will be constructive—that their uses will advance the purposes of all mankind. Then, and only then, can we say—a job well done!"

Research a "Creative Force"

NEW YORK, N. Y.—The accelerated pace of industrial research and development since World War II undoubtedly has influenced the nation's "prolonged cycle of advancing business activity," the technical director of General Motors Research Staff told the Society of Automotive Engineers.

The speaker, John M. Campbell, said economics are beginning to recognize research as "a creative force". "This is at once a responsibility and an opportunity because herein lies the key to future progress," he declared.

He explained that in 1925 when the research idea was just beginning to make itself felt in the (automotive) industry, the average life of a car was about seven years and after 25,000 miles the car was ready for the scrap heap. "Today," he said, "we have more than doubled the car life and the modern car is good for a total of 125,000 miles of service to its various owners all along the line before it finally ends up in the scrap pile.

"Although the price of the car today in terms of real dollars is of the same order as its predecessor, it is a much better car in every respect and is good for five times as much transportation," Mr. Campbell told SAE members. "In other words," he added, "the net result of all the research and engineering, including development of manufacturing methods, has been the delivery with each new car in 1955 of five cars for the price of one in 1925."

In view of the enormous demand for gasoline, Mr. Campbell explained, General Motors for the past 25 years has underwritten a large research effort to give the motorist more miles of travel per gallon of gasoline. This effort has included investigation of the influence of molecular structure of fuels, flame and combustion studies, ignition timing, air-fuel ratio, combustion chamber design, valve cooling, piston cooling, transmission and axle design.

By utilizing all these research factors to the utmost, the speaker said, the automotive industry has raised engine compression ratios in passenger cars from a 1930 average of 5-to-1 to a 1955 average of 7.8-to-1, and the trend is still upward. Compression ratio rises have produced more miles per gallon of automotive travel, a research dividend to the motorist.

Furthermore, he said, GM Proving Ground tests under actual highway traffic conditions over a 300-mile course have shown an average increase in "tank mileage" of from 13.5 miles per gallon in 1933 to 18.6 per gallon in 1954. "This," he said, "is an improvement of 40% in miles per gallon, not to mention the improved performance, comfort and appearance of the more recent automobiles.

Research for the Home

Roger Keyes, GM Vice President, foresees "tremendous things on the horizon" through advances in electronics, atomic energy and other fields of technology.

- "Soon it will be possible to close your windows in case of rain by dialing your home number on the telephone. Or utilize automatic window closers sensitive to the first raindrop."
- "Equipment that will convey, sort, clean, iron and fold laundry."
- "Equipment that will wash floors automatically and perform other drudgery-ending operations for the housewife."
- "A fully autonomous house with its own source of power, atomic or solar; its own water and sewage disposal system independent of well or main; and of course facilities to make housekeeping all but effortless."

Research such as that underway at the GM Technical Center, Mr. Keyes said, "has brought to reality far stranger dreams."

Materials are dried in a horizontal stainless steel chamber in contact with a hot air stream. Control panel is under the cat-walk (left) and the centrifugal and multi-cyclone collectors are connected with the discharge end (right) of the chamber.

Spray Drying Techniques for Chemicals And Foods Under Study

PITTSBURGH, PA.—A pilot plant size horizontal spray dryer with nozzle atomization will be used for developing techniques in spray drying chemicals, pharmaceuticals, foods and other materials. The Buflovak Equipment Division (Buffalo) officials of Blaw-Knox Company say that in addition to all of the normal advantages of a spray dryer, such as fast drying at minimum temperatures to prevent product degradation, the new unit has other significant features in solving drying problems. First, extreme flexibility in application to products that can be atomized through a nozzle. Second, it requires no more head room than is normally available in industrial plants. Third, ease of cleaning cuts maintenance costs and time.

A wide variation of air flow, nozzle pressure, spray pattern and other general operating conditions provide flexibility of operation.

Camera To Screen In Sixty Seconds

BOSTON, MASS.—A logical extension of the Polaroid Land camera is expected to change picture viewing habits in homes, schools and business conference rooms.

Dr. Edwin H. Land, president and director of research of Polaroid Corporation, demonstrated a new film that produces black-and-white transparence slides for projection on a screen a minute or two after the shutter is snapped.

With the new film and the simplified projector that completes the system, the Land process produces pictures for big-screen projection as quickly as it produces paper prints.

The new film removes the delays and uncertainties that have kept projected pictures in the hands of the professional, to be brought out only for special occasions scheduled in advance and worth the considerable delay and expense that have been involved up to now.

The film is also the first to combine extremely high speed with ultra-fine grain. Under close-up examination, the projected pictures "held together" and showed freedom from the usual grain-structure.

Dr. Land also cited a number of activities in commerce and industry where he expects the new system to have immediate value in communication of ideas. He predicted that business meetings would rely much more heavily on visual presentations since an entire report or program can be put on slides in a matter of minutes, just before the meeting for group viewing.

As an example of uses in teaching, he projected a slide of a newspaper article, typical of one which a teacher can pick out of the morning paper enroute to school, to snap and project for his current events class.

One slide showed a machinery layout, used at an engineering conference for an entire group to judge and appraise simultaneously.

Another example was a copy of an X-ray. Among advantages in this field, he mentioned that a small, critical portion of an X-ray can be projected greatly enlarged, yet extremely sharp, to facilitate medical consultations. He also pointed out that while X-ray photographs almost always have great over-all contrast, any small area of special interest to the doctor may have only limited contrast and can often be made more useful if rephotographed and projected at higher contrast to bring out more details.

The new transparency film can be used in any of the existing Polaroid Land cameras. Company officials stated that it will be made available shortly.

Glass Research: Away With the Pinches of Salt

TOLEDO, OHIO—The era of data gathering in the art and science of formulating glass products and processes is quickly drawing to a close. According to J. W. Hackett, Director of research, Owens-Illinois, the major emphasis of researchers will be in fundamental research that can do away with the "pinches of salt" in techniques for developing new compositions. Techniques such as X-ray diffraction, neutron diffraction, infra-red transmission and reflection, heat capacity measurements, nuclear radiation and other techniques will be hurled at the barriers in an attempt to develop a rational approach in this field.

New uses for glass based on research into its untapped strength were foreseen by Oscar G. Burch, Owens-Illinois Vice-President. Glass as a structural material with the load-bearing strength of steel at slightly less than the weight of aluminum was a possibility pointed up in talks and displays at the dedication of the Owens-Illinois Technical Center.

Three Research Results

As examples of progress made by its intensified research program, Owens-Illinois announced three new commercially practical developments:

- A new process for making glass containers 20% lighter, but still stronger than similar containers made by any other method and at double the present production rate.
- A low temperature solder glass for use on color television bulbs. The solder provides a perfect, lifetime seal between the two pieces of glass which can be opened and resealed. One immediate benefit is the promise it holds for production of low-cost color television picture tubes.
- A heat-treating process which makes glass containers more durable, opening up new packaging opportunities.

Burch said that three basic factors point the way to the new era in glass: (a) an inexhaustible supply of raw materials for glass, (b) a strength potential many times greater than anything presently attained in commercial production and (c) the unique advantageous, natural properties of glass.

Explaining the untapped potential strength of glass, Mr. Burch said. "Although scientists have been able to realize 75% of the theoretical strength of glass, the industry has been able to attain only about 1% of this strength in commercial production of glass bulk articles. When we learn how to attain 2% of these highest measured values, theoretically all glass products of proven satisfactory commercial strength can be made at half their present weights. When we learn how, by modifying glass structure, or by other means, to attain 10% of this potential, we are firmly convinced that glass will really come into its own as a structural material," he said.

"If we can secure just a fraction of its presently proven mechanical strength, it will be used for purposes not now even dreamed about."

Studies on glass structure are one of the most important phases of research work at the new Center, which allows, for the first time under one roof, a complete cycle of glass research and engineering from pure theory to production tests under actual commercial conditions.

The two-story structure, housing drafting rooms, offices, 50 laboratories, and a mammoth plant in its 200,000 square feet of floor space, is staffed by 500 scientists and technicians.

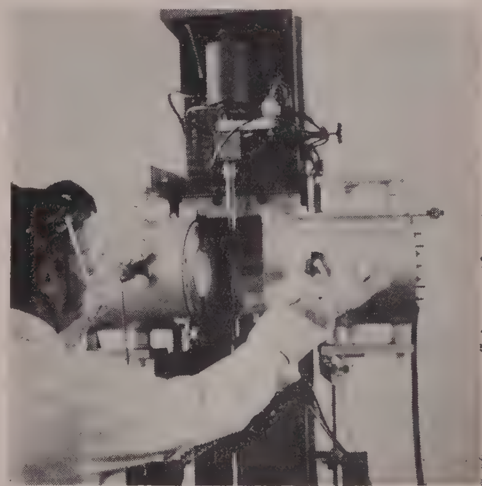
C. R. Megowen, Owens-Illinois president, pointed out that fundamental studies at the Center, plus the work on improving present manufacturing processes, and the development of processes for manufacturing new products should lead to greatly expanded glass uses.

"When we consider that glass is usually made from nature's most abundant materials, we see no reason why the expansion of the use of glass into new fields should be retarded through anything other than a lack of understanding as to how to develop and use it," he said.

The possibilities of future uses for glass were dramatized in a display based on the premise that man will eventually have to go beyond his present living environment to find new living space and new supplies of resources to support an ever-increasing population.

A highlight was a scale model of a city in the Antarctic depicting industrial, business and residential sections under glass domes and joined by interconnecting tubes of glass.

Glass containers, 20% lighter and just as strong, are produced by a new Owens-Illinois process. This is achieved on the experimental machine, above, which "right-weights" glass containers. The commercial model under construction, will about double present glass container production rates.



Owens-Illinois scientists are conducting expensive research into the strength of glass. Glass is introduced to this experimental equipment in an effort to study its temperature and rate of pull. By holding one constant, the rate of pull, for instance—and changing the temperature, it is possible to chart a complete performance of glass at one rate of pull.

The pilot plant of the new Owens-Illinois Technical Center, viewed from above, is a maze of experimental equipment. The pilot plant represents the final stage in the complete cycle of research at the new Center. This battery of experimental forming machines, fed by two 25-ton furnaces, is capable of producing 75 tons of glass products daily.

Book Reviews

Process Engineering Economics

BY HERBERT E. SCHWEYER

Reviewed by Max S. Peters
Assistant Professor Chemical Engineering
University of Illinois

Cost and profit analyses are extremely important in any type of engineering work. Too often, engineers, whether in research, development, production or administrative positions, have little training in applied economic procedures. Many do not understand the basic ideas and principles underlying industrial economics, and, therefore, can make only rough and superficial analyses of cost data. Here is a book that can remedy this situation. Professor Schweyer presents a detailed analysis of engineering economics in the process industries, giving not only basic principles of applied economics, but also example problems that apply these principles in cost and profit decisions.

The first part of the book deals with the basic elements in applied economics. Analyses of the value of money, amortization and capital requirements are presented in detail. The next chapters discuss costs and profits, replacements and alternatives. Over one-third of the book is devoted to economic balances. The final chapters deal with the application of economic analyses in complete process operations.

The principles discussed are illustrated by practical applications in various types of process industries, including petroleum processing, chemical production, plastics, pharmaceuticals, mineral dressing, metal refining, food processing and ceramics manufacturing. A number of unsolved problems are presented at the end of each chapter to give the reader a chance to test himself on his understanding of the subjects covered.

The treatment of optimum economic balances is exceptionally good, and the explanation of the methods for determining optimum conditions is very clear and complete. The various subjects in the book are carefully cross-referenced to indicate sources of additional information.

Unfortunately, many of the illustrative examples are difficult to follow because they require reference to other examples presented earlier in the book. The author also has the disconcerting habit of presenting two methods for solving the same problem without discussing why different results are obtained. Admittedly, many economic results depend on the particular method used, but, in a book of this type, it would have been very helpful if the author had strayed from the middle of the road occasionally to indicate the "pros" and "cons" of the various procedures.

For the management engineer and the practicing engineer, this book is a source of ideas for effecting savings in design and operation. It is valuable as a reference for the terminology of applied economics and will be useful to the engineer who wishes to understand the theoretical economic principles as applied in the practical use of cost analyses.

McGraw-Hill Book Company, Inc., New York, N. Y., 409 pages, $7.50.

Proceedings of the Eighth Annual Conference on the Administration of Research

Reviewed by Merritt A. Williamson
Manager Research Division
Burroughs Corporation Research Center

In the fall of 1954 New York University acted as host to the Eighth Annual Conference whose five sessions were devoted to proven practices in the area of research and development. As each speaker was alloted 15 minutes for remarks, the published records make pithy reading.

At the first session the problem of appraising and rewarding the researcher's output ("Who Gets a Merit Raise?") was discussed from the viewpoint of the university, industry, the research institute and the government, as exemplified by the Bureau of Standards. Also the British system of prizes and awards was described by a member of the Defense Research Board of Canada. The problem of matching the worker's rewards with his contribution necessitates finding a way to determine this creative productivity in an area subject to the usual ups and downs of progress. All systems discussed employed some form of subjective rating. Rewards of a non-monetary nature were described; for example, provision for advanced study, attendance at technical meetings, promotion, sabbatical years, knighthoods, fellowships in learned societies, medals and participation on patent royalties.

The second session dealt with management in the research laboratory. The objectives of "Work Simplification" were presented to see what application, if any, they might have in the research area as well as in production. The control of service groups was discussed with respect to efficient size, handling of peak loads, scheduling, assigning of priorities and the balancing of work done internally against that purchased outside. The relation of research to production and sales departments was discussed and the committee system advocated. A presentation of the qualifications of an engineering manager and a review of management problems in a large industrial laboratory ended this session.

The third session was devoted to communication problems in a research operation. A procedure was given for the preparation of oral presentations; their importance was highly stressed. Illustrative examples were given of how the Armed Services Technical Information Agency has helped industry save thousands of dollars by preventing unnecessary research. ASTIA may well prove helpful to any organization in getting hard-to-come-by information, to say nothing of the dollars saved. Principles for good internal and external communication were presented with the latter emphasized. One speaker cited the value of various forms of reports; the next described The Director's Weekly Bulletin which contributed government experience with the communication problem. The session concluded with a discussion of problems peculiar to communication in areas of research under government security regulations.

In the fourth session physical facilities for research were treated. The new Johns Hopkins Laboratory was described with the difficulties encountered in its planning. Those who contemplate building a new laboratory may learn from this account a few of the stumbling blocks to avoid. An architect next presented some of the more subtle considerations in designing buildings for research such as modular planning, site selection and construction with appeal to creative occupants. The establishment of a small committee to make unified decisions was strongly urged. In the final presentation the Johns-Manville experience was detailed. It was claimed that extra money for landscaping and niceties in the offices of managers and supervisors is certain to pay off handsomely in the

resulting boosted morale.

The final session discussed the role in an applied research laboratory of basic research—defined by the first speaker as the link between fundamental and applied research. To the second speaker it was obvious that basic research must come from applied research and that basic data must be deliberately sought. The example of the development of cortisone is an interesting account of the effective application to achieve practical results of basic research done cooperatively by academic and industrial research people. The experience and philosophies of Bell Telephone Laboratories and the National Lead Company complete the proceedings.

New York University Press, New York, N. Y., 108 pages, $4.00.

Industrial Purchasing

BY J. H. WESTING AND I. V. FINE

Reviewed by J. Cammarata, Department Head R/D Section and C. Hagman, General Purchasing Agent, ARMA Division, American Bosch Arma Corporation

In engineering parlance this volume could be titled "The Purchasing Man's Handbook" for its completeness of scope. The authors with their contributing staff have filled the void between theory and practice with a book that encompasses the field of purchasing with a flexibility of coverage such that a "one man" or a "multi-plant" operation can benefit from it.

Functional and operational criteria for purchasing personnel are set forth logically in terms of company organization with a collection of staff diagrams, flow charts, quantity ordering calculators, inventory control systems, quality control criteria, and bibliography references indicative of an analytical engineering approach. The chapters on "Major Equipment" and "Commodities" provide a ready reference and a working vocabulary of terms for the ever pressed purchasing personnel who are called upon to buy the proverbial "soup to nuts".

The engineer's role in purchasing is well expressed and dynamically illustrated. It is refreshing to see that expert purchasing personnel refer to experts in other lines to prepare specifications for commodities or services to be bought. These specifications are the tools in the hands of purchasing personnel equivalent to lathes in machinists' hands. Complex test equipment, extremely precise components, specialized services, construction work peculiar to advanced engineering development—these are the items passing daily over the desks of P.A.'s in research, engineering and manufacturing concerns. From the text: "Engineers . . . have positive ideas about the physical and chemical properties required in the end product . . ." One can see that the authors appreciate the engineers' assistance in preparation of specifications and evaluation of incoming bids. This appreciation can be realized by purchasing personnel in the form of expeditious and economical buying.

The authors' projection of purchasing personnel into a company atmosphere in place of the commonly thought of Purchasing Department hermetic seal is deserving of a verbal bouquet. To quote: "A close working arrangement must be developed between these two departments. The engineering department should not be so exacting that its demands override price and market considerations. On its part, the purchasing department must not stress price to the point where it interferes with basic engineering principles.

"The two departments should complement each other, and close cooperation is essential for smooth and successful relationships. Good engineering produces a product up to company specifications, with both technical and market efficiency."

The book can best be described as a text that tells what is to be done, details how it is to be done, and then describes a method of determining whether it was done to the best overall efficiency and economy.

John Wiley and Sons, Inc., New York, N.Y., 421 pages, $7.50.

Nuclear Energy Texts

The gradual release of a relatively large amount of hitherto classified information in the area of nuclear energy has resulted in the updating of existing texts in nuclear physics and chemistry and the publication of new ones particularly in the area of reactor design. Information recently released by participating countries at the Geneva Conference on Atomic Energy will probably generate, after a suitable time lapse, more texts of this type. But for the present here are some that can function as basic or reference texts. For the engineer or chemist who contemplates work in these areas for the first time, the books will be of definite assistance.

Principles of Nuclear Reactor Engineering

BY SAMUEL GLASSTONE

D. Van Nostrand Co., Inc., New York, 861 pages, $7.95.

For the practicing engineer who wishes to know something of the impact of nuclear energy upon his professional activities and the student who wants to study the chemistry, physics and engineering principles of nuclear reactor systems.

Nuclear and Radiochemistry

BY G. FRIEDLANDER AND J. W. KENNEDY

John Wiley and Sons, Inc., New York, 468 pages, $7.50.

A revised (1949) version of "Introduction to Radiochemistry" covers the chemist's viewpoint: radioactivity, nuclear reactions, nuclear states and radioactive processes, detection and measurement, statistical considerations, radionuclide techniques, tracers and cosmic problems.

Nuclear Physics

BY IRVING KAPLAN

Addison-Wesley Publishing Co., Inc., Cambridge, Mass., 609 pages, $8.50.

Written for use as a text in an advanced undergraduate course for physicists, engineers and chemists. Part I (seven chapters) deals with background information; Part II (ten chapters) covers the physics of the nucleus; Part III (five chapters) treats special topics and applications such as neutron physics, fission, charged particle accelerators and isotope separation.

Introductory Nuclear Physics

BY D. HOLLIDAY

John Wiley and Sons, Inc., New York, 493 pages, $7.50.

A second edition of a 1950 publication; intended for an undergraduate course.

Electrotechnology

BY M. G. SAY

Reviewed by Herbert Spirer Engineering Physicist, CGS Labs

The introduction to this volume states that here is a brief presentation of the electrotechnical basis of phenomena having importance in light and particularly heavy electrical engineering. This remark is misleading; within the class of electrical engineers, only the power engineers could possibly regard this as a basic reference. Electronic conduction in gases is not discussed, but the specialized technique of symmetrical components covers 11 pages. The concept of Q, or magnification, of a resonant circuit is bypassed in a sentence while calculations pertaining to three phase power circuits occupy several pages.

What does this book offer to the power specialist? There is a remarkably lucid summary of the physical basis of modern conceptions of electricity, a superficial treatment of fundamental relations of physics, a satisfactory section on units and definitions. Under the heading "Electrotechnics" are shallow dissertations on thermal effects; resistance; electrochemical, magnetic and electric field effects. Tables of appropriate constants and configurations of some elementary magnetic and electric fields are derived.

The second part of the text considers simple rather than basic networks, and without analyzing the occasionally troublesome situations involving mutual inductance. The final chapters cover sym-

metrical components, transients and use of the loci of complex functions.

Even the power engineers will be disappointed with this book; it contains less basic information than any of his first year college texts, and has the disadvantage of unfamiliarity. Electrical engineers of other specialties will have little use for the volume.

Philosophical Library, New York, N. Y., 167 pages, $6.00.

Applied Thermodynamics

BY E. B. NORRIS, E. THERKELSEN AND C. E. TRENT

Reviewed by Gilbert S. Bahn
Senior Thermodynamics Engineer
Marquardt Aircraft Company

This volume is the third edition of a text formerly entitled "Heat Power" and is a welcome revision up to the present of the second edition, which appeared in 1939. The new title is intended to indicate the primary purpose of the book as development of "an understanding of the fundamentals of thermodynamics as applied to power generation from heat sources". Unfortunately the title is more sweeping in scope than intended; the process industries, for example, apply thermodynamics widely outside the field of power generation.

The authors have continued the previous arrangement whereby they begin with descriptive discussion of internal combustion engines and lead from there through fuels and combustion to the treatment of thermodynamic fundamentals, from which they proceed to theoretical and actual performance of internal combustion engines. This approach is a neat way to set up the introduction of thermodynamics, and much surpasses the pure philosophical-mathematical approach. However, the exposition of thermodynamics given is perhaps too non-elegant, although generally adequate for the applications made. One might wish for at least a passing reference to entropy as a measure of random distribution of energy, as well as a specific measure of unavailability of energy. Furthermore, believers in the Third Law won't like the phrase, "there is no zero of entropy", however convenient it may have been to the authors.

The text is concerned with applied aspects of power generation, and considers hardware in considerable detail, using a nice selection of illustrations from a wide range of sources. To the previous editions has been added a new chapter on compressors, following the half of the book devoted to steam power and associated topics.

Insertions to various of the chapters on the internal combustion engine deal in condensed form with the gas turbine, chiefly by way of acknowledging, it seems, the emergence of this powerplant to a position of some importance between editions. Surely the attention is out of balance, if balance were intended, with the details presented for reciprocating engines. Furthermore, the most recent dated reference on gas turbine performance is eight years old, and there is not even a reference for the claim, "It has been estimated that the maximum operating temperature of the gas turbine for long-life commercial service in powerplants is about 1350°F". This needs qualification in all directions: fuel type, state-of-the-art regarding materials application, definition of "long-life" and even whether the authority was referring to inlet or outlet temperature.

In summary, here is a good, up-to-date readable text for a course in heat power, nicely illustrated and containing a multitude of problems (with tables of properties of working fluids for their solution). The thermodynamics is presented bite sized and sugar coated, with emphasis on hardware in reciprocating internal combustion engines and steam power plants.

McGraw-Hill Book Co., Inc., New York, N. Y., 490 pages, $7.50.

Atomic Energy— A Realistic Appraisal

Published in "verbatim style" the proceedings of a recent meeting entitled "Atomic Energy—A Realistic Appraisal" will be of interest to those companies now in atomic energy or contemplating such activity. The meeting, for members only, was held in late May 1955 and was devoted to an evaluation and interpretation of the Forum's "Growth Survey of the Atomic Industry, 1955-1965."

Industry and government estimates of the impact of an expanding atomic industry on private and government research and development activities, reactor component manufacture, fuel preparation and processing and special problem areas were presented.

Atomic Industrial Forum, 260 Madison Ave., New York, N.Y., $5.00, paper-bound.

Handbook of Engineering Materials

EDITED BY DOUGLAS F. MINER AND JOHN B. SEASTONE

Arranged by classes of related or similar materials, the first section gives general information on specifications and standards, statistics in the application of materials and mathematical and physical tables. The second is devoted to pure metals, special purpose metals and alloys; the third, to non-metals; the last, to construction materials including cementing and roadbed materials, timber, rope, foundations and glass products.

John Wiley and Sons, Inc., New York, N.Y., 1382 pages, $17.50.

The Gyroscope Applied

BY K. I. T. RICHARDSON

Reviewed by Arthur Sommer
Arma Division, American Bosch Arma Corporation

The author states that his book does not constitute an exhaustive treatise on the gyro in theory and practice, for he seeks to explain the theory of the gyroscope and to describe its practical application in a manner understandable by all with any interest in the subject.

His work then becomes an introduction to gyros and their application on a very general level. The applications discussed center mainly around the shipboard gyrocompass and the usual airborne gyro instruments. To the American reader, however, the impression is that the British, if this truly represents a cross-section of their gyro instrumentation, have made very few state-of-the-art advances since World War II. The text does not include the fluid suspended gyro, for example, which represents a significant advance in this country. The discussion of Naval fire control stabilization gyro instruments is essentially restricted to comparing them with airborne gyro instruments when they are quite dissimilar. In addition, the author summarily dismisses the true-north seeking gyro compass as unsuitable for aircraft application, when in fact the true-north seeking gyro compass as envisioned in this country is a very practical instrument for aircraft even when flying at supersonic speeds over the magnetic northpole.

The book is recommended, however, for the beginner in gyroscopes for background information.

Philosophical Library, New York, N. Y., 384 pages, $15.00.

Review of Current Research And Directory of Member Institutions 1955

Every two years the Engineering College Research Council reviews the research programs in our engineering colleges. This latest publication covers 105 institutions working on approximately 7,500 research projects. Research at our universities employs the efforts of over 15,000 faculty, graduate students and research engineers at a cost of approximately $75 million annually. For each institution the book lists the fields of research covered, administrative offices, policies governing research projects, personnel, expenditures, sources of income, special conferences and other pertinent information.

Order from Renato Contini, Secretary Engineering College Research Council, New York University, University Heights, New York 53, N. Y. Price $2.00.

Research Reports

Reports in this section may be obtained directly from the Office of Technical Services, U.S. Dept. of Commerce, Washington, D. C., unless another source is stated.

Measuring Thermal Conductivity of Gases

A mathematically derived method for measuring thermal conductivity of gases, independent of radiation and therefore particularly suitable for use at elevated temperatures, is described in a report of research done by Columbia University for the Office of Naval Research.

The method employs a conventional hot wire cell with its wire heated by a sinusoidal alternating current superimposed upon a direct current. Mathematical calibration equations are used to determine optimum cell design and operating conditions under which it is theoretically possible to obtain the thermal conductivity of gases at high temperature from electrical responses which are sensitive to thermal conductivity but insensitive to wire-to-wall radiation.

Sections of the report are devoted to the mathematical analysis of the differential equation and accompanying boundary conditions, measurement of magnitudes and phase angles of temperature waves, analysis of calculated data and graphs, conditions for evaluating optimum ratio of direct current to superimposed alternating current, evaluation of radiation assumption and the heat capacity of gas. Appendixes give solutions of equations, log graphs and summary of principal methods of measuring thermal conductivity of fluids.

The Measurement of the Thermal Conductivity of Gases at High Temperature, *PB 111571, 34 pages; $1.00.*

Radiation Sterilization of Foods Surveyed

A survey of the scientific literature in the field of radiation sterilization, a process which promises to revolutionize food preservation, is contained in four Government research reports.

Experimental treatment of foods such as meat, dairy products, vegetables and flour with low doses of radiation has resulted in extended storage life. Meat can be stored for several weeks after such treatment. The radiations also serve as growth inhibitors to eliminate or delay potato and onion sprouting.

So rapidly has the literature on the effects of ionizing radiation increased that it has become almost an impossibility for any one investigator to keep abreast of new discoveries, developments and future possibilities and applications within this field, it is stated by the Quartermaster Food and Container Institute for the Armed Forces, who prepared this four-volume bibliographic series.

The first volume is a review of research in the fields of proteins, lipids, carbohydrates, meats, vitamins and enzymes. It gives a brief comprehensive survey of the progress of radiation sterilization as it stands today.

The second and third volumes constitute the bibliography itself, containing 4,357 references, while the fourth is a subject index to the bibliography.

Radiation Sterilization—Review of Literature in Selected Fields, *PB 111634, 77 pages; $2.00.*

Bibliography on Ionizing Radiations
Part I, PB 111635, 266 pages; $6.75.
Part II, PB 111636, 320 pages; $8.00.
Part III, PB 111637, 281 pages; $7.25.

Magnetic Ceramics

A study conducted at Massachusetts Institute of Technology of the properties of certain ferromagnetic compositions and how far the manufacturing processes affect their magnetic and electrical characteristics is discussed in a report of Government-sponsored research.

Ferromagnetic semiconductors have become extremely important in meeting the rigid specifications of modern electronic applications where the conventional ferromagnetic materials have failed. In this study magnetite, manganese ferrite and magnesium ferrite together with 13 compositions within the system Fe_2O_3-MgO-MnO were investigated.

A carbonate decomposition method of obtaining a well-dispersed oxide mix of high reactivity was used. Ferrites were also prepared and fired in various controlled atmospheres. Magnesium ferrite and one complex composition were investigated under a variety of conditions and showed an increase in the initial permeability and a decrease in the coercitive field with increasing peak firing temperature and firing time.

When fired at 1450°C., the maximum induction increased, but the permanent induction fell off, especially for the complex composition. A similar decrease of remanent induction was noted by quenching from above 800°. Oxygen loss or gain over the stoichiometric amount produced a loss of magnetic properties in all the ferrites investigated.

A Study on Magnetic Ceramics, *PB 111625, 61 pages; $1.75.*

Nonferrous Metals for Low Temperature Use

Research into low temperature properties of certain nonferrous metals about which very little is known has been conducted under Signal Corps contract to determine the best materials for service use at low ambient temperatures.

These studies indicate that tantalum can be used with safety at temperatures down to —100°F., without impairment of its mechanical qualities. Tantalum, both sheet and wire, showed excellent fatigue qualities, a high endurance ratio and tensile properties that improved with decreasing temperatures.

Low temperature studies of nilvar, a nickel-base alloy often used in telephone diaphragms, are of special interest since almost no literature exists on this subject. Nilvar sheet and bar and beryllium copper appeared to have good low temperature properties with proper control of modulus of elasticity of nilvar and grain size of copper.

Other metals tested at temperatures ranging from 80°F. to —100°F. included nickel and nickel base alloys, tin, tungsten, molybdenum and germanium.

Studies in the Behavior of Certain Nonferrous Metals at Low Temperatures (Final Report, Volume 1) *PB 111657, 157 pages, $4.00.*

Gamma Rays Used To Vulcanize Rubber

Two Air Force research reports describe use of atomic radiation to vulcanize natural and synthetic rubber and the search for new ways to produce rubber that is resistant to fuel, oil and hydraulic fluids at extreme temperatures.

The first report reveals that high-intensity gamma radiation of rubber, a brand new vulcanizing technique, has produced elastomers with markedly better resistance to dry heat and oil aging than

chemically vulcanized compounds. Many experimental polymers which resist chemical vulcanization may be readily vulcanized by this process. It has been found that uncured vulcanizable elastomers may be cross-linked without chemical vulcanizing agents and high curing temperatures. The elastomers are uniformly vulcanized by the penetrating power of high energy gamma rays. No residual radioactivity is imparted to the elastomer, and maintenance problems, with proper shielding, are comparatively simple. The unique physical and functional properties of elastomers prepared by this process are described in this report, and compounding formulas and test data are shown in tables.
Vulcanization of Rubber With High-Intensity Gamma Radiation, *PB 111675, 37 pages; $1.00.*

First steps in an exploratory study of boron polymers are described in this literature survey undertaken as a preliminary to detailed laboratory study and experimentation. The broad objective of this research was to isolate new hydrolitically stable polymeric materials of exceptional fuel and oil resistance, and high thermal stability. The survey included studies of inorganic and semi-organic polymers and rubbers, with emphasis on the chemistry of boron compounds. Most practical approach to the preparation of high temperature polymers appeared to be through the use of boron compounds based on amide linkage. Recent study of alkylated phosphino-borines indicates that these are a promising field for further investigation.
Research on Boron Polymers—Literature Survey, *PB 111689, 58 pages; $1.50.*

Acoustic Noise Control

A comprehensive and up-to-date study of the generation and control of noise and its effects on human behavior includes sections on sound absorptive properties of materials, new designs for acoustic shielding structures, transmission of sound through cylindrical shells, ventilating fans and systems and noise generated by axial flow compressors.
Handbook of Acoustic Noise Control, Vol. I, Physical Acoustics, *PB 111200S, 315 pages; $8.00,* **Vol. II, Noise and Man,** *PB 111274, 271 pages; $3.00.*

Study of Fiber Structure By Stress Relaxation

Stress relaxation behavior of natural and synthetic fibers including nylon, dynel, dacron, textile rayon and ramie in distilled water, hydrochloric acid and in some cases in sodium hydroxide, sodium fluoride, lithium chloride and other reagents of varying concentrations under a variety of temperatures was investigated to determine the physical and molecular structure of these fibers.

Various methods of interpreting the stress-relaxation behavior of textile rayon are considered in addition to the interpretations based upon the existence of an order-disorder distribution. Experimental data agree with the assumption that cellulose contains a distribution of ordered material ranging between the crystalline and amorphous states.
Stress Relaxation of Fibers as a Means of Interpreting Physical and Chemical Structure, *PB 111655, 233 pages; $6.00.*

Multicoupler Sensitivity Loss

Two reports. The first describes a widely applicable method for determining sensitivity loss when active type multicouplers are used to permit operation of several receivers from a single antenna. The method considers the effect on receiver sensitivity of noise voltages generated within the multicoupler, multicoupler "gain" and the sensitivity of the original system. A standard formula is worked out for determining the merit of a multicoupler in relation to its effects on the sensitivity of a receiving system, and procedures are described for determining limitations and optimum performance of a specific multicoupler unit.
A Standard Method for Determining Multicoupler Sensitivity Loss, *PB 111541, 16 pages with charts: $.50.*

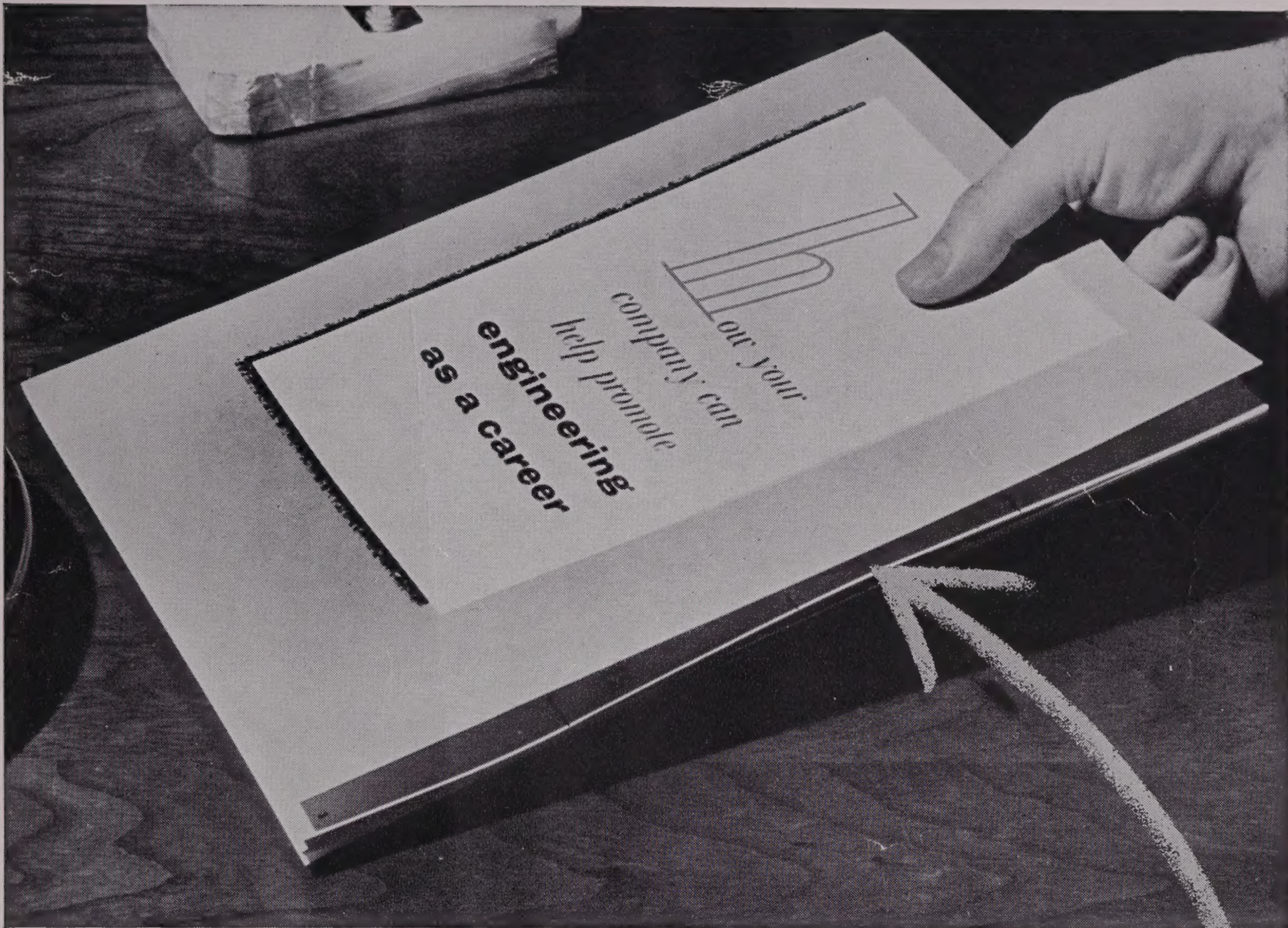
The second explores non-linear resistors as terminating elements for linear prototype filters and performance of lattice reactive element networks using non-linear inductance.
Nonlinear Elements and Filter Networks, *PB 111673, 115 pages; $2.75.*

Foamed-in-Place Core Materials

The most promising method for producing foamed-in-place sandwich structures from silicone resins consists of expanding a dry powdered resin containing blowing agent, catalyst and inert filler. The powder melts and expands readily on heating. Core density can be controlled by adjustments in the expansion temperature. The expansible powder produces a stable, uniform multipore foam with a pore structure predominantly spherical and unicellular. None of the materials or by-products is toxic. The foams have low moisture absorption along with excellent electrical properties and are nonflammable. Thermal life of the core is over 1000 hours at 600°F. with no appreciable weight loss or dimensional change. Weight loss of the core after 72 hours at 700°F. is below 6%.
Development of a Heat-Resistant Foamed-in-Place Low-Density Silicone Resin Core Material, *PB 111555S, 115 pages; $3.00.*

Cellulosic Cushioning Materials

Seven cellulosic materials used to cushion sharp-cornered items packed in desiccated packages were tested at 100°F and 95% relative humidity to determine the amount of water vapor sorbed when silica gel desiccant was absent and when present but on the side of the cushioning material opposite the humid air. The silica gel increased water vapor flow through the cushioning material and as such initially increased moisture pickup of that material about 11 times over what it would have done with such silica gel absent. A moisture pickup by the cushioning material some 20% that of the desiccant was noted when both were present in the package.
Sorption of Water Vapor by Cellulosic Cushioning Materials, *PB 111661, 11 pages, $.50.*



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The booklet reproduced here was prepared by The Advertising Council in cooperation with the Engineers' Joint Council to help you make your advertising work most effectively in recruiting engineers for the future.

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2. It outlines the advantages of an engineering career to help your company develop advertising appeals.
3. It informs you as to the current activities of industry in the education and recruitment of engineers.
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A SAFE DELIVERY FOR "THE PREGNANT GOOSE"

This Lockheed Super Constellation, nicknamed "The Pregnant Goose," is one of the U.S. Navy's radar picket planes. It is now equipped with a remarkable new navigation instrument that makes its job of air defense a safer and more efficient one.

This new navigation instrument is called the Dead Reckoning Tracer. It was designed, developed and manufactured by Servo Corporation of America at the request of the U.S. Navy.

The Dead Reckoning Tracer automatically plots the course and position of the aircraft. A glance at the DRT chart is all that is needed to determine the exact geographical position of the plane at any moment of the flight, and the precise distance and direction the plane has flown up to that particular moment.

In producing the Dead Reckoning Tracer, Servo Corporation of America solved the intricate, precision problems of manufacture by devising special patented processes and tools. In fact, *there were no test runs,* because the very first components that came off the production line met every tolerance requirement. It is interesting to note too, that Servo Corporation of America bettered the original military specifications for the Dead Reckoning Tracer.

Servo Corporation of America is now directing its resources to meet the needs of industry for advanced Electronic Control Systems and Components. One of the few companies with genuine diversity of engineering talent, Servo Corporation of America offers industry the benefits of its engineering skills, specialized manufacturing facilities and patented processes in the design and fabrication of electro-mechanical systems, components and assemblies. Perhaps we can serve you.

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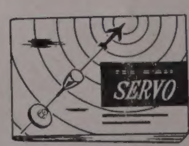
If you'd like to learn more about the research, engineering and production skills and facilities at Servo Corporation of America, send for booklet, "This is Servo." Please indicate in which of the above fields you are most interested. Write to:



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